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Noise Exposure of Civil Aircarrier Airplanes Through the Year 2000
Volume I: Methods, Procedures, Results

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FEBRUARY 1979

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16. ABSTRACT

This report presents results of an estimate of the national exposure to aircarrier aircraft noise through the year 2000. The forecast was carried out to show the effect of two types of noise abatement options. The first consisted of modifications to FAR Part 36 proposed to the Federal Aviation Administration (Notice 76-22) by the U.S. Environmental Protection Agency which would establish lower noise limits for newly designed aircraft in the years 1980 and 1985. The second type consisted of alternative power cutback procedures (FAA AC 91-39 and two variations of ALPA/Northwest Airlines procedure) coupled with minor variations on approach procedures.

The effect of these proposed options was evaluated from estimates of the total area or number of people exposed within selected day/night average noise level contours around all of the nation's airports. The analysis assumed future aircraft just meet the various noise rules considered. It also included: (1) two levels of fleet growth; (2) a national model for noise exposure using statistically average airports; and (3) a model for population density around aircarrier airports based on 1970 census. The study emphasized noise exposure for subsonic aircarrier aircraft; however, a brief analysis is also shown for the isolated exposure of only supersonic aircraft operations which would result from a worldwide fleet of SST aircraft resulting from only 16 Concordes to a total of 100 SST aircraft.

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1.0 EXECUTIVE SUMMARY

1.1 Program Objectives

One objective of this study was to forecast the national noise exposure due to aircarrier aircraft through the year 2000 in terms of land area and number of people exposed to specified sound levels. A second objective was to evaluate the effectiveness of existing aircraft noise certification rules as well as rules proposed* by the EPA (United States Environmental Protection Agency) for future implementation. The estimates of area and population exposure are primarily intended to accurately indicate the relative exposure levels for a variety of proposed noise abatement actions. The estimates of absolute values of national noise exposure presented in this study are also considered to be the most accurate presented to date and supersede previous estimates carried out for EPA by Wyle Laboratories. Noise exposure estimates were made for two different projections of air traffic growth, for three different flight procedures, and for three alternative schedules of aircraft noise certification rule introduction representing application of existing, available, and future aircraft noise reduction technology. The study emphasized noise exposure of subsonic aircarrier aircraft. However, a special evaluation was also made of the isolated noise exposure from supersonic aircraft with similar noise rules applied.

1.2 Methods

Estimates of national noise exposure area and population were made using computer calculation methods based on four average airports constructed to represent general classes of aircarrier airports across the country. These average airports, called AVports, were constructed from parameters at actual airports within each AVport class. Noise exposures were calculated at a grid of locations surrounding these AVports for various scenarios of flight procedures, noise rules, and aircarrier activity from 1975 to 2000. The number of people exposed to various sound levels was found by deriving population versus area functions for each of the AVports based on previous studies. The population around the AVports was derived from 1970 U.S. Census Tape information for population around actual airports and projected to future years using conservative population growth figures from the U.S. Bureau of Census.

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*FAA Notice No. 76-22, "Proposed Regulations Submitted to the FAA by the Environmental Protection Agency: Noise Levels for Turbojet Engine Powered Airplanes and for Large Propeller Driven Airplanes," Federal Register 41:47358, October 28, 1976, plus subsequent corrections.

The procedure used to estimate the noise exposure due to aircarrier operations can be summarized as follows:

- The nation's aircarrier airports were classified according to the type of aircraft using each airfield.
- For each class of airports, average runway lengths and flight tracks were defined from data at sample airports which as a group contributed approximately 20 to 100 percent of the aircarrier operations in each airport class.
- Three scenarios for noise rules applicable only to newly designed aircraft were defined. Noise levels for all such newly designed aircraft were assumed to just comply with the limits specified in these noise rules.
- Two scenarios for future aviation activity levels were developed from recent FAA (U.S. Federal Aviation Administration) publications.
- A population versus area function around the average airports for each class was developed from population information taken from the 1970 U.S. Census Tapes and previous airport noise studies.
- Utilizing the Wyle Integrated Noise Model computer program, noise exposures around the average airports were calculated in terms of total contour area. The number of people exposed to various sound levels was then computed from the preceding population versus area functions.
- Finally, the noise exposure estimates developed for the AVports were scaled up to provide estimates of the national exposure due to aircarrier aircraft.
- A total of 97 separate estimates of the national noise exposure were computed covering:

- Five years from 1980 to 2000, in 5-year increments, plus a base year, 1975.
- Three scenarios for noise rules (current 1975 FAR Part 36 plus the rules for 1980 and 1985 proposed by EPA).
- One additional case for the year 2000 in which all aircraft were assumed to comply with the "1985 rule" proposed by EPA.
- Three different power-cutback operating procedures for takeoff (FAA AC91-39, and minimum and maximum cutback versions of the ALPA/Northwest Airlines procedure). Approach procedure variations were also included.
- Two different projections of the future aircarrier fleet (moderate or expansive growth).
- One conservative projection of future population (approaching zero population growth).

- The portion of the study which considered supersonic aircraft evaluated the isolated noise exposure at a limited group of airports for SST aircraft operations only, with application of the same noise rules analyzed for subsonic aircraft.

1.3 Conclusions - Subsonic Aircarrier Aircraft

This portion of the study has focused on evaluation of the possible effectiveness in reducing aircraft noise exposure by two basic approaches: application of new aircraft source noise reduction technology and utilization of improved noise abatement takeoff procedures. For the former approach, the study was limited to evaluating the effect of imposing progressively lower noise limits on all newly-designed aircraft (requiring a new type certification) introduced after 1975.

In no case was it assumed that newly manufactured aircraft of existing types, which now make up the fleet, had to be retrofitted except as required by the existing rules of FAR Amendment 91-136 which require all existing aircraft to comply at least with the 1969 FAR Part 36 noise limits by 1985.

The relative changes in source noise levels dictated by the proposed noise rules can be roughly defined as follows in terms of the takeoff noise limits (for source noise at takeoff power conditions with cutback), sideline noise limits (for source noise at maximum takeoff power conditions), and approach noise limits (at approach power settings). The relative levels consider only those applicable to the current aircarrier aircraft fleet.

	Relative Noise Levels, dB		
Noise Rule	Takeoff	Sideline	Approach
1969 FAR Part 36 (Stage 2)	0	0	0
1975 FAR Part 36 (Stage 3)	-3 to -7	-6	-4
1980 Proposed EPA Rule	-6 to -10	-12	-8
1985 Proposed EPA Rule	-10 to -14	-12	-11

If such noise reductions were applied to all of the aircraft operating today, the decrease in noise exposure would be marked indeed. For example, average source noise reductions of 5, 9 and 12 dB, corresponding very roughly, to the average relative levels in the preceding table, would be expected to decrease the exposure area within the L_{dn} 65 contour, nationally, from a reference value of 100% to about 38%, 17% and 10%, respectively. However, the existing FAR Part 36 limits for 1975 (identified as Stage 3 in FAA rules and as Technology Level 1 for purposes of this study) and the proposed 1980 and 1985 rules are all applied only to newly designed aircraft. Therefore, the relatively slow rate of dilution of the existing fleet with these newly designed and quieter aircraft, coupled with reasonable estimates of a forecast growth in aircarrier operations, provides less decrease in total noise exposure by the year 2000 than would be suggested by these numbers. Nevertheless, the estimated decrease in exposure effected by the proposed rules would be substantial.

Considering only the "moderate growth" scenario for the future aircarrier fleet, and assuming the takeoff Procedure Level 1 (FAA AC91-39), the change, from the 1975 reference point, in the estimated total area and total population exposed by the year 2000 is shown in Table 1.3-1 for each of the three technology (noise certification) rules considered.

Table 1.3-1

Summary of Estimated Reduction in Noise Exposure Within L_{dn} 65 dB Contour by Year 2000 as a Function of the Applied Technology Level[**]

			Exposure Within L_{dn} 65 Contour			
			Area		Population	
Year	Technology Level	Certification Rule	Mi^2	%	10^6 People	%
1975	Base	1969 FAR Part 36	2169	100	6.17	100
2000	1	1975 FAR Part 36[*]	1304	60	3.58	58
2000	2	1980 Proposed Rule	1200	55	3.11	50
2000	3	1985 Proposed Rule	1157	53	2.95	48
2000	3A[‡]	1985 Proposed Rule	626	29	0.92	15

[*] Stage 3 in FAR Part 36 Terminology

[‡] All aircraft assumed to comply with noise levels specified by the 1985 Proposed Rule

[**] For Moderate Growth Scenario of future fleet using flight Procedure Level 1 (See Section 3.5.2)

The additional decrease in exposed population (48% re 1975 base) achieved by imposing the 1985 (Technology Level 3) rule beyond that effected by the 1980 rule (50% re 1975 base) is small due to the relatively small portion of the aircarrier fleet in the year 2000 which would have been certified under the more stringent noise rule. Just as it will take roughly 20 years for aircraft noise reduction technology to be significantly influenced by the original 1969 FAR Part 36 rules, so would it take a corresponding period of time for the proposed 1985 rule to have a significant influence. (Even the 1969 FAR Part 36 rule is not yet fully effective due to the remaining number of aircraft still flying which cannot meet the required noise levels.) Nevertheless, the projected effect of imposing the 1985 rules would be a reduction in exposed population of about 50 percent, from 1975 values, by the year 2000. The reduction in exposed area is slightly less. An approximate indication of the maximum potential for noise reduction of the 1985 rule is provided by the one special case (Technology Level 3A) for the year 2000 where it was assumed that all aircraft in the fleet meet the 1985 rule. In this case, as indicated in the preceding table, the decrease in exposure is much greater. Note especially that the decrease in population is now much greater (15% re 1975 base) than the decrease in exposed area (29% re 1975 base). This is due to the reduced population density as the contours shrink down nearer to the airport. This effect is even more significant since the national population (and corresponding population density) is assumed to increase by 22 percent from 1975 to the year 2000. Thus, without this increase, Technology Level 3 would have reduced the exposed population to 39 percent instead of 48 percent of its 1975 value for the corresponding 53 percent reduction in exposed area..

Allowing for a 6-year lag between the effective date for new type certifications required by the 1985 rule and the first substantial introduction of newly designed aircraft responsive to this rule and another 20 years for the aircarrier fleet in existence at that time to be completely replaced by these newer aircraft, one could expect that the full effect of the proposed 1985 rule would not be felt until at least the year 2010.

In contrast to this necessarily slow but inexorable process for reducing aircraft noise exposure, the potential benefit of improved noise abatement takeoff procedures is more immediate and, as indicated in Table 1.3-2, of significant benefit. For simplicity, the table shows the change in area and population within the L_{dn} 65 contour for the year 1980 assuming Technology Level 1 (FAR Part 36 Stage 3) and for the year 2000 assuming Technology Level 3 (1985 proposed rule). The moderate growth case is assumed for both years.

Note that for the year 1980, the ALPA/NWA Maximum Cutback (Procedure No. 2) shows a substantial reduction in exposed population (70 percent re 1980 AC91-39 base) within the L_{dn} 65 contour. However, by the year 2000, when source noise levels have been reduced, this takeoff procedure is only slightly better than the AC91-39 procedure. This is consistent with the fact that for both 1980 and the year 2000, AC91-39 (Procedure No. 1) is significantly more effective than the ALPA/NWA Max

Procedure (by 15 to 20%) in reducing exposed population within the L_{dn} 75 contour. Thus the AC91-39 procedure seems to be more suited for noise abatement close in to an airport where the single event levels are higher while the ALPA/NWA Max Procedure appears best suited for areas further away from the airport where more people are exposed to lower single event levels.

Table 1.3-2

Summary of Estimated Change in Noise Exposure Within
L_{dn} 65 dB Contour by Year 2000 as a Function of the
Power Cutback Flight Procedure on Takeoff**

			Exposure Within L_{dn} 65 Contour			
			Area		Population	
Year	Takeoff Procedure	Proced. Level	Mi^2	%	10^6	%
1980 *	AC91-39	1	1873	100	5.22	100
1980	ALPA/NWA Max	2	1536	82	3.67	70
1980	ALPA/NWA Min	2A	1829	98	5.05	97
2000†	AC91-39	1	1157	62	2.95	57
2000	ALPA/NWA Max	2	1142	61	2.80	54
2000	ALPA/NWA Min	2A	1306	70	3.55	68

* Moderate Growth and Technology Level 1 (FAR Part 36 Stage 3) Assumed
† Moderate Growth and Technology Level 3 (1985 proposed rule) Assumed
** Effects of the Various Approach Procedures are also included (see Page 3-45)

The summary results shown in Tables 1.3-1 and 1.3-2 were based on the moderate growth case for the future aviation fleet. The results are very similar for the expansive growth case.

In summary, the application to subsonic aircarrier aircraft of the noise technology certification rules for 1980 and 1985 proposed by EPA will show a substantial decrease in noise exposure in future years but the full effect will not be felt until well beyond the year 2000. A more immediate achievement in airport noise reduction is possible by using an improved takeoff flight procedure. While the optimum procedure will be a function of a particular airport's demographic environment, the proposed ALPA/NWA Max Cutback procedure offers additional noise reduction on an average for the nations airports over that provided by the AC91-39 procedure for current technology aircraft. The optimum takeoff procedure may tend to change with years, calling for application of power cutback closer in to airports as source noise levels are reduced.

1.4 Conclusions – Supersonic Transports

This portion of the study, documented in Appendix E, evaluated the change in exposed area and population at a select group of 13 U.S. airports considered as potential candidates for operations of the Concorde aircraft. A total world-wide fleet varying in size from 16 to 100 was considered along with evaluation of a do-nothing case (current Concorde Technology assumed), and imposition of the 1969 FAR Part 36 (Stage 2) rule, the 1975 FAR Part 36 Stage 3 rule (Technology Level 1 for the subsonic aircraft), and the proposed EPA 1980 rule (Technology Level 2 for the subsonic aircraft) to all but the first 16 SST aircraft which represented an existing Concorde fleet. The noise exposure generated by just these 16 Concorde aircraft alone was increased by only 6% in area and 19% in population (within the L_{dn} 65 contour) by the addition of as many as 84 more SST aircraft to the fleet, with a corresponding increase of 525% in operations, providing these additional SST aircraft conformed to at least the 1969 FAR Part 36 rules. When these additional aircraft were further quieted to conform to the 1975 FAR Part 36 rule or the proposed 1980 EPA rule, the exposed area and population within the L_{dn} 65 contour for a total fleet size of 100, with 16 Concordes, increased above the baseline value for 16 Concordes by only 2 to 12%. Thus, the noise exposure of the basic Concorde fleet would tend to completely dominate the noise exposure of possible SST operations in the U.S. which include existing Concorde type aircraft and any reasonable number of other SST aircraft which complied with existing or proposed noise rules. Without the Concorde aircraft, noise exposure of other SST operations would decrease substantially in direct proportion to the level of the applicable noise rule.

2.0 INTRODUCTION

2.1 Purpose and Objectives

The objectives of this study were to estimate the national noise exposure due to aircarrier aircraft through the year 2000 and to evaluate the effectiveness of existing noise certification rules for aircraft as well as that of several noise regulations proposed by the EPA. Noise exposure was estimated in terms of total area and number of people exposed to specified sound levels. These noise exposure projections represent a range of possible noise exposures that might occur under various economic and regulatory conditions through the year 2000. The study was not intended to predict the most probable noise exposures for future years but rather to focus on changes in exposure as a result of regulatory action. Emphasis was placed on evaluating noise exposure for subsonic aircarrier operations and this constitutes the main body of this report. A separate evaluation of noise rules on exposure of potential supersonic aircarrier operations in the U.S. is treated in Appendix E.

The proposed noise rules being examined for this study have appeared in FAA NPRM-76-22 which was published in the Federal Register 41:47368, October 28, 1976. Corrections to this NPRM subsequently appeared in the Federal Register 41:53807, December 9, 1976.

2.2 Relation of this Study to Other EPA Work

This study was part of EPA's effort to provide an estimate of the national noise exposure through the year 2000 due to all aircraft sources. To accomplish this overall objective, the various types of aircraft operations such as aircarriers, general aviation, and military operations at civil airports will be analyzed individually in separate studies. This study focuses on the aircarrier activity alone.

Two previous studies of national noise exposure which were carried out by Wyle Laboratories for the EPA were also designed to examine the effect of various aircraft noise abatement alternatives.[3, 26] The relative changes in noise exposure for future years for the various noise abatement options considered in these previous studies are compared to results of this study in Section 4.4. The type of noise abatement actions considered and the methods for estimating current and future noise exposure employed in these previous studies were not the same as for this study. Thus, the relative trends in future noise exposure are only roughly comparable and estimated absolute values of exposed area and population are not directly comparable. The current study is considered the most accurate basis for absolute estimates of exposed area and population and, in this respect, supersedes these previous studies.

2.3 Scope of Project

National exposure estimates were prepared for six time periods starting in 1975 (base case) and extending to the year 2000 in 5-year intervals using the Wyle Integrated Noise Model (INM) computer program.*

The noise exposure projections developed in this study were based on established noise and performance data for existing aircraft types under consideration. For aircraft yet to be developed, performance characteristics were assumed to be similar to aircraft in the existing fleet and noise characteristics were assigned so that new aircraft would just meet the appropriate noise rules for the scenario under study. No attempt was made to precisely estimate the noise and performance characteristics of future aircraft based on design details of proposed aircraft.

The projections reflect the total exposure due to aircarrier jet aircraft operations at all airfields in the country that have greater than about 20 annual aircarrier jet operations. Noise exposures from propeller aircraft, business jets, helicopters, and military aircraft were not accounted for in the noise exposure projections developed for this study.

A total of 96 different alternative cases were examined in addition to a base case. These cases represented all possible combinations of

- Three noise rule alternatives
- Three flight procedure alternatives

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*This is the early version of the airport noise mapping program refined and recently published by FAA as the Integrated Noise Model (Version I)[16]

- Two alternative projections of aircraft activity level

for each of five study years. Six additional cases for the year 2000 were examined, one each for the three flight procedures and two activity levels, in which all aircraft were assumed to comply with the most stringent noise rule currently being proposed. Table 2.3-1 summarizes the different cases that were evaluated.

2.4 General Approach to Estimating Area and Population Exposure

The basic approach to estimating the national exposure due to aircarrier aircraft was to calculate exposure values at average airports and then scale these average airport results to the nation as a whole. The first step in this procedure was to divide the nation's airports into four classifications according to the types of aircraft that use the airport. From the sample airports, average runway geometries, flight track geometries, trip length distributions, and day/night operations ratios were developed. Future levels of operations and fleet mixes were developed from FAA publications.[1,2] After defining the operations for all study alternatives, noise exposure levels were calculated using the INM computer program for each average airport in terms of area and population exposure. Finally, the exposure estimates at the average airports were scaled up to provide an estimate of the total national exposure.

2.5 Report Organization

The conclusions reached in this study and a description of the general methods used are presented in the main body of this report. A considerable amount of background material and supporting data have been included as appendices to this report. The following outlines the general organization of the remainder of this report:

Section 3 defines the methods and procedures used for the entire study; Section 4 provides the detailed results; and Section 5 summarizes the principal conclusions that can be made from the data. The following supporting appendices are provided in Volume II.

Table 2.3-1

Summary of Cases Considered

Years	Aviation Activity Levels			Noise Rule Alternatives				Flight Procedures			AVports		
	(6,24, 25)* 1975	(1) Moderate Growth	(2) Expansive Growth	(22) 69	(23) 75	(14) 80	(14) 85	(15) AC 91-39	(15) ALPA/NW Max. Cutback	(15) ALPA/NW Min. Cutback	A	B	C
1975 (Base)	X			X				X			X	X	X
1980		X	X		X	X	X	X	X	X	X	X	X
1985		X	X		X	X	X	X	X	X	X	X	X
1990		X	X		X	X	X	X	X	X	X	X	X
1995		X	X		X	X	X	X	X	X	X	X	X
2000†		X	X		X	X	X†	X	X	X	X	X	X

* Numbers in parentheses ( ) designate references for source of data.

† An Additional Case was run for the Year 2000 Assuming all Aircraft Conformed to the 1985 Noise Rule

- Appendix A – List of Airports by Class
- Appendix B – Fleet Forecast Methods
- Appendix C – Aircraft Noise Data
- Appendix D – Aircraft Performance Data
- Appendix E – Supersonic Aircraft Noise Exposure
- Appendix F – Detailed Results of Scenario Analyses at the AVports and Extrapolations to National Estimates

3.0 METHODS AND PROCEDURES

3.1 General Description of Procedure Used to Estimate Noise Exposure

The procedure used to estimate the noise exposure due to aircarrier operations can be summarized in general terms as follows:

- The nation's aircarrier airports were classified according to the type of aircraft using each airfield.
- For each class of airports, average runway lengths, flight tracks, and mix of aircraft types were defined from observations at sample airports in each class.
- Three scenarios for introduction of noise rules were defined.
- Two scenarios for possible aviation activity levels were developed from recent FAA publications.
- A population versus area function around the average airport for each class was derived from population information taken from 1970 U.S. Census Tapes.
- By using the INM computer program, noise exposures around the average airports were calculated in terms of total contour area and number of people exposed to various sound levels computed from the preceding population versus area functions.
- Finally, the noise exposure estimates developed for the AVports were scaled up to provide estimates of the national exposure due to aircarrier aircraft.

The details of the projection method are presented in the following sections.

3.2 AVport Definitions

3.2.1 AVport Concept

There were two alternative methods available for estimating the national exposure due to aircraft noise. The most straightforward of these would have been to perform a noise exposure calculation for each airport of interest in the country and then sum up the exposures from these airports. The alternate approach was to develop some sort of model airports, estimate the noise exposure for these models, and then scale the results to the nation as a whole. Since the former approach was clearly impractical, the latter was used for this study.

Three alternative methods were available for defining the model airports. The first was to pick one or more real airports and consider them as representative of all airports in a given class. The difficulty with this approach was that there was no way to determine how representative the selected airport was of the rest of the airports in the nation, short of calculating the exposure due to the other airports. The second method available was to "average" all pertinent parameters of the national airports of interest. The difficulty with this approach was that it was very difficult to average spatial parameters such as runways and flight tracks. In the event that the runway locations were averaged directly without first assuming a basic runway configuration such as parallel or crossed runways, the average airport might contain a large number of runways. Such a configuration would spread the noise exposure over an unrealistically large area and understate the noise exposure at the larger distances from the airport. A third method available to define a model airport was to assume the model airport had a single runway and straight in and out flight tracks. The difficulty with this method was that the noise contours resulting from this model would be much longer than those at a real airport since an unrealistically large number of operations would be placed on a single runway and flight track. This would overstate the noise exposure at large distances from the airport.

For this study, a combination of the second and third methods mentioned above was adopted to develop the model airports. A single runway was used to simplify the problem of developing an average runway layout. However, in recognition of the problem that a single runway would distort the results, the single runway model was assumed to represent an average runway rather than an average airport. The model airports, referred to as AVports, were essentially models of the busiest runway at all the airports under consideration. By taking this approach, the number of operations placed on the runway could be limited to the physical capacities of the runways and operations on other runways could be accounted for by use of a scaling factor. In addition, flight tracks with turns were included to simulate the natural dispersion of flights around real airports, both for landing and takeoffs.

3.2.2 AVport Classes

The first step in developing the model airports was to classify the nation's airports according to aircraft types using the airports. There were several reasons for developing these classes. First, in order to evaluate the national exposure of SST (supersonic transport) aircraft, candidate airports for SST operations were to be analyzed as a separate group. An average airport class, called AVport A, was constructed for this purpose. Next, airports prohibiting operations of particular aircraft types (4-engine) were to be analyzed as a separate group. A class, called AVport C, was defined for this purpose, and turned out to represent primarily the nation's smaller airports. This class was further divided into sub-classes, C-1 and C-2, for computational purposes. The remaining airports fell into a third class, called AVport B. The names of all of the airports in each of the above classifications are tabulated in Appendix A.

This approach to classification represents a change from the approach used in previous work, in which AVport classes were constructed according to numbers of operations regardless of the type of aircraft.[3]

The three airport classes used in this study to represent the nation's aircarrier airports were defined as follows:

Class A – SST candidate airports. These airports include those identified by the FAA as candidate airports for SST operations[4] as well as Philadelphia. There are 13 airports in this class and sample data from all 13 were used in developing the AVport which was called AVport A. A separate class for SST candidate airports was necessary in order to identify the contribution of SST aircraft to the total national noise exposure. The airports in this class are listed in Table 3.2-1.

Class B – Airports allowing all aircraft except SSTs to operate. This class represented the larger airports where all classes of aircraft are found. There are 113 of these airports in the nation and the 15 airports chosen as samples of this class are also listed in Table 3.2-1. This class was called AVport B.

Class C – Airports where 4-engine jets do not operate. This class represents smaller airports offering limited service due to restricted runway length, noise consideration, or insufficient demand for long range service. The sample airports for this class are listed in Table 3.2-1. As a further refinement, the Class C airports were subdivided into categories C-1 (comprised of the two airports, La Guardia and Washington National) and C-2 (comprised of 179 airports). This was necessary because the C-1 airports were not similar to the other Class C airports. In all three classes, airports with less than 20 jet operations per year were ignored. The two AVports for this class were called AVport C-1 and AVport C-2.

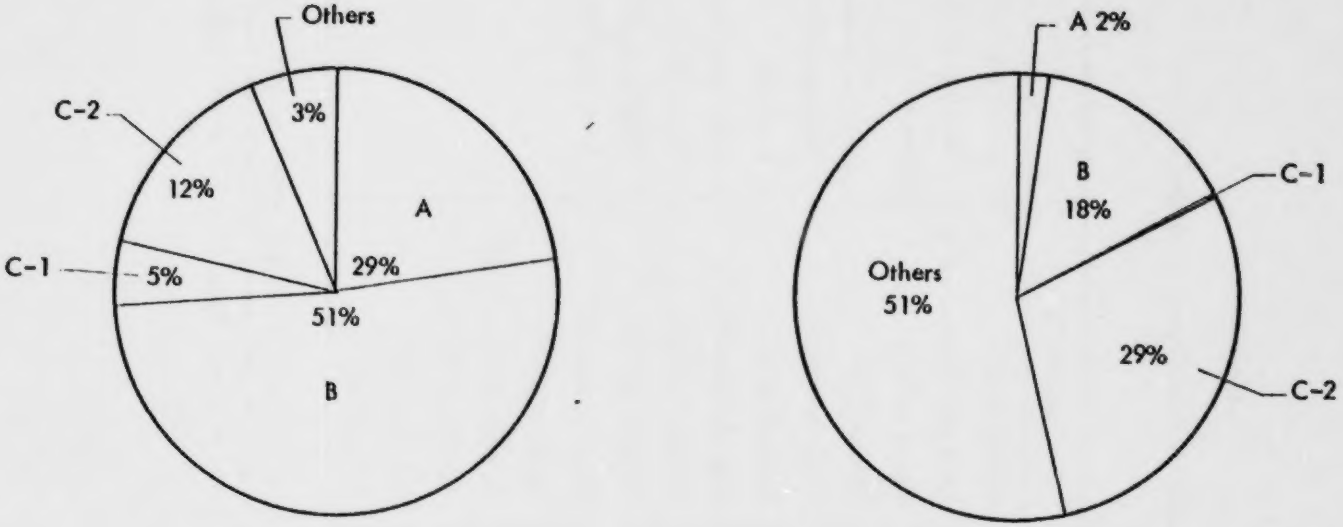
Figure 3.2-1 shows how the nation's operations are distributed among the AVport categories and also shows what percentages of the nation's airports are in each AVport category. This figure shows that while only about 49 percent of the nation's aircarrier airports fall within these classes, 97 percent of the national operations occur

Table 3.2-1

Sample Airports Chosen for Study*

AVport A	AVport B	AVport C-1
Anchorage (ANC)	Buffalo (BUF)	New York (LGA)
Boston (BOS)	Colorado Springs (COS)	Washington, D.C. (DCA)
Chicago (ORD)	Denver (DEN)	
Dallas-Ft. Worth (DFW)	El Paso (ELP)	AVport C-2
Honolulu (HNL)	Little Rock (LIT)	Chicago (MDW)
Houston (IAH)	Newark (EWR)	Erie (ERI)
Los Angeles (LAX)	New Orleans (MSY)	Hollywood-Burbank (BUR)
Miami (MIA)	Oakland (OAK)	Ithaca (ITH)
New York (JFK)	Ontario (ONT)	Melbourne (MLB)
Philadelphia (PHL)	Palm Springs (PSP)	Santa Ana (SNA)
San Francisco (SFO)	Portland (PDX)	
Seattle-Tacoma (SEA)	Raleigh-Durham (RDU)	
Washington, D.C. (IAD)	San Diego (SAN)	
	San Jose (SJC)	
	Tulsa (TUL)	

*This sample was used only for evaluating the average schedule, approach procedure and trip lengths for air traffic activity and runway configuration at each AVport. Total operations and aircraft mix data were based on a 100 percent sample for all airports (see Section 3.3).



Percent of Operations at AVport Classes A, B, C-1, and C-2

Percent of Certified Aircarrier Airports Within Categories A, B, C-1, and C-2

Figure 3.2-1. Relative Importance of AVport Classes

at these airports. The figure also shows that airports in AVport B category represent about one-half of the nation's aircarrier operations.

After defining the airport classes, sample airports listed in Table 3.2-1 were chosen from each class. These samples were used to develop a data base for describing the following parameters of the AVport model: runway length, approach procedure, day/night distribution of operations, and trip length distribution. (Total operations and aircraft mix data were based on a 100 percent sample of all airports in each class as explained in Section 3.3.) Choosing samples for AVports A and C-1 presented no problem since data were available for all airports in each class and since the classes were small enough to permit examination of all airports in each of these classes. For AVport B, however, there were too many airports in the class to examine each one and there was no detailed operational information for many of these airfields. Consequently, a set of sample airports was chosen in the following fashion. Airports in AVport B class were divided into four subclasses based on the number of operations at the airfields. Then, sample airports were chosen at random from each size class until approximately 20 percent of the total operations were represented by sample airports. This method provided some assurance that the samples represented all sizes of airports within each class and not just the larger or smaller airports. Figure 3.2-2 quantifies the size (number of operations) ranges for AVport B that are represented by the sample airports.

Choosing sample airports for AVport C-2 presented some difficulty because detailed information was not available for a sufficient number of airfields in each size class. Consequently, sample airports were chosen solely on the basis of data availability. Figure 3.2-3 illustrates that the AVport C sample airports are more representative of the larger airports in this class.

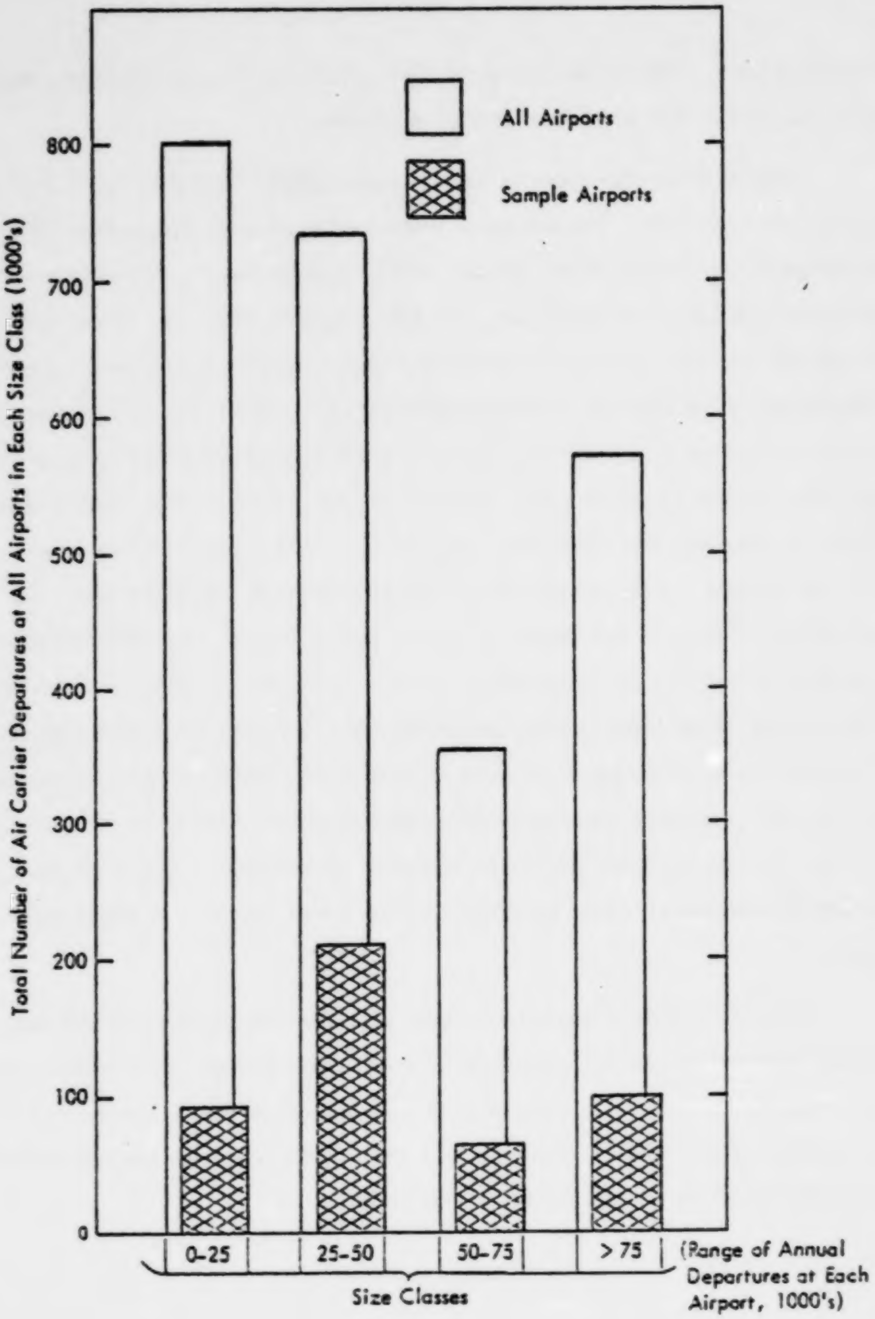


Figure 3.2-2. Distribution of Operations at Different Size Classes of AVport B Airports

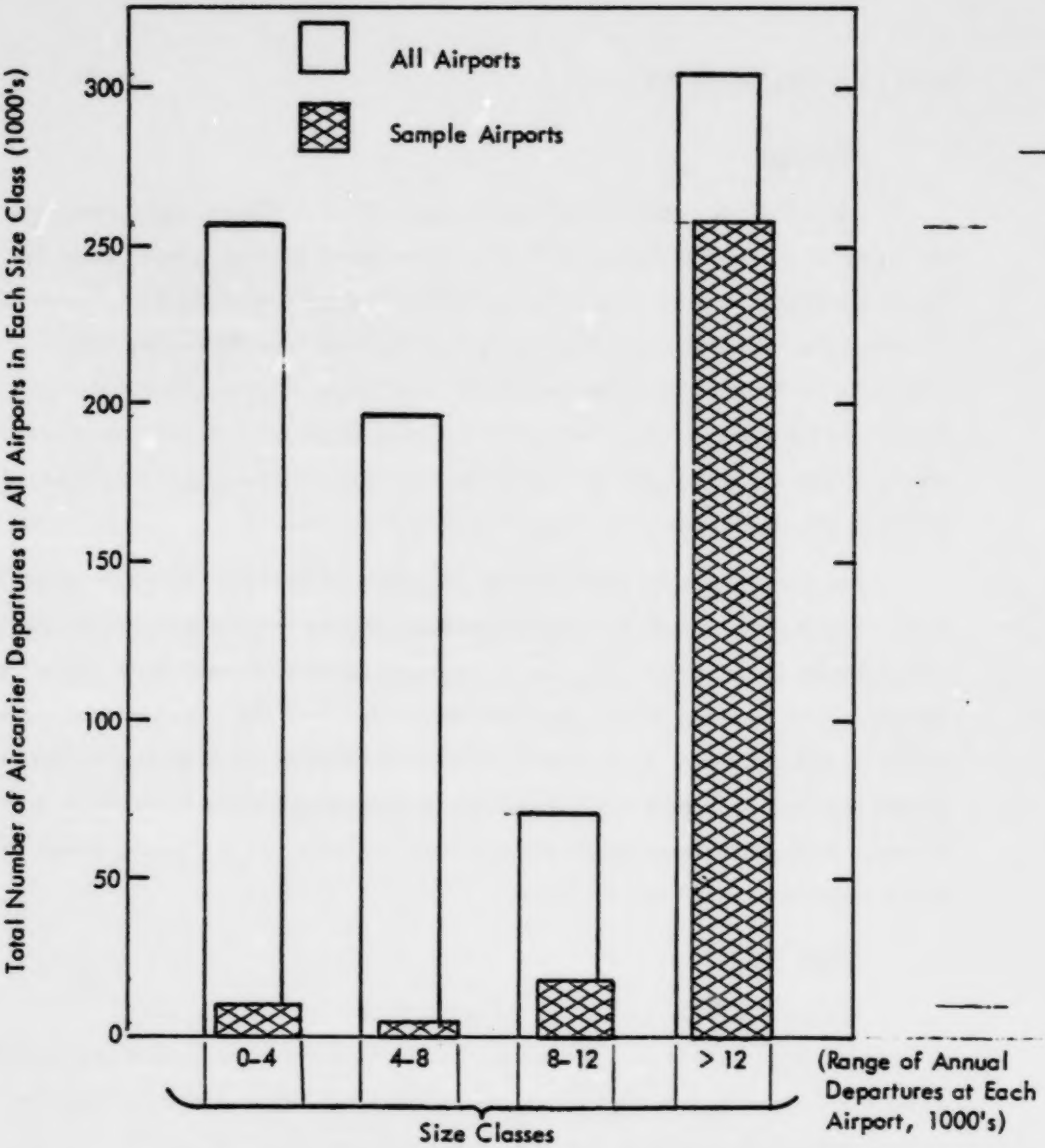


Figure 3.2-3. Distribution of Operations at Different Size Classes of AVport C-1 and C-2 Airports Combined

3.2.3 AVport Parameters

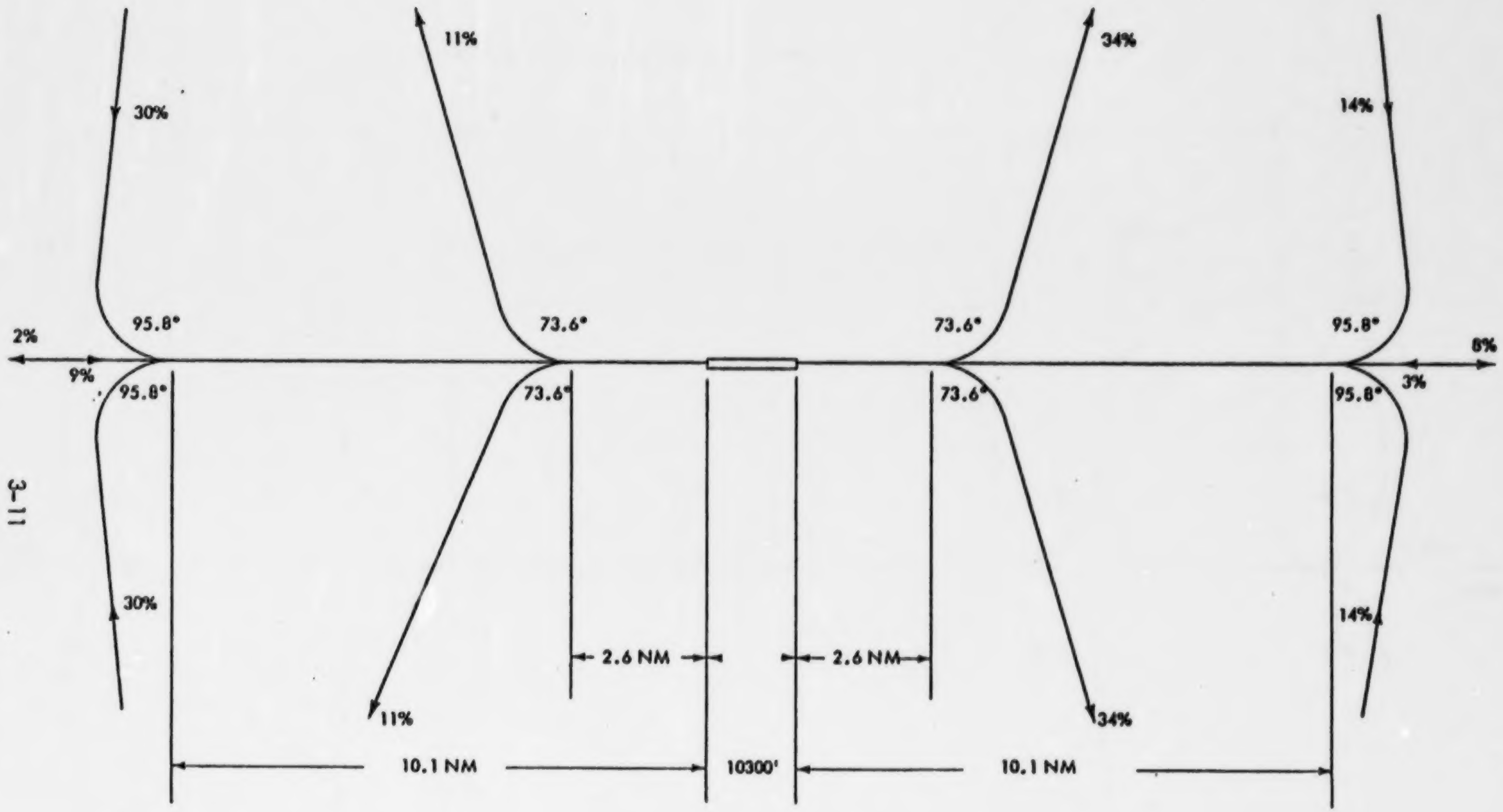
Runways

By definition, each AVport had a single runway. The average runway was developed for each AVport class by finding the weighted average runway length for the sample airports in each class. For example, if takeoff operations from Runway 01 at a particular sample airport were 4 percent of the total takeoffs from all sample airports in the AVport class, then Runway 01 would be given a weight of .04 when calculating the average runway length for this class of airports. A weighted average runway length was calculated for each AVport category and the results are indicated on the runway layouts shown in Figures 3.2-4, 3.2-5, and 3.2-6.

Because the runways at the AVports represent weighted average runway lengths of all runways at the sample airports, the runway length at the AVport may be less than that necessary for operation of the heaviest aircraft at some of the airports within the category. This apparent discrepancy is of no concern since the primary purpose of the runway length definition in the AVport model is to establish the relative positions of the takeoff and landing thresholds for operations in opposite directions along the AVport runway. Sufficient runway length was provided internally in the computer model to permit takeoffs of all classes of aircraft.

Flight Tracks

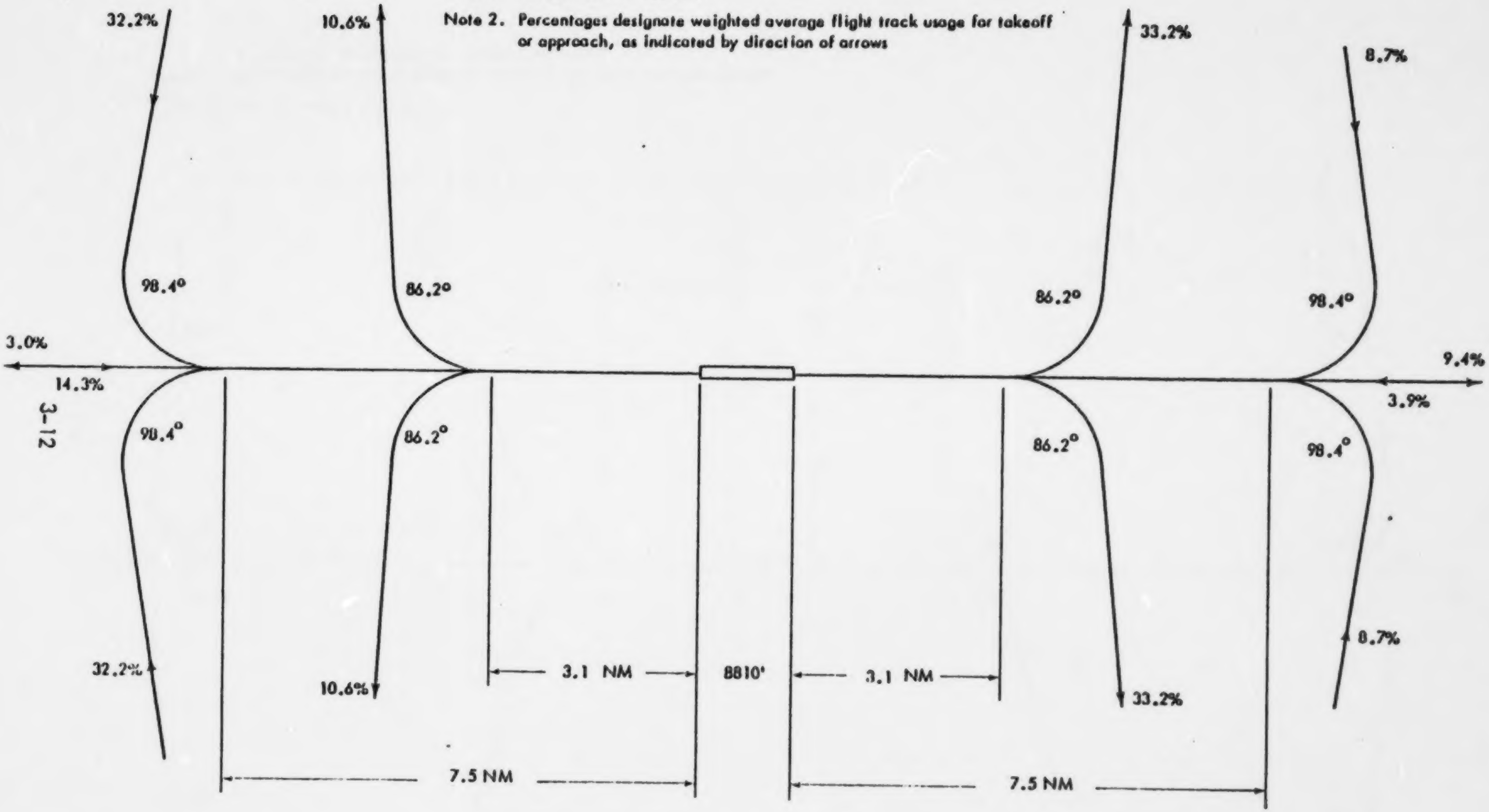
Flights at each AVport were assumed to follow one of three takeoff or three landing tracks in each direction. Except for the straight landing and takeoff tracks that follow the extended runway centerline, each flight track consisted of a straight segment leading away from the airport followed by a turn to either the right


30%
11%
34%
14%
2%
95.8°
73.6°
73.6°
95.8°
8%
9%
95.8°
73.6°
73.6°
95.8°
3%
30%
14%
2.6 NM
2.6 NM
11%
34%
10.1 NM
10300'
10.1 NM

Note 1. All turn radii = 1.5 NM

Note 2. Percentages designate weighted average flight track usage for takeoff or approach, as indicated by direction of arrows

Figure 3.2-4. AVport A Configuration



32.2%
10.6%
33.2%
8.7%
98.4°
86.2°
86.2°
98.4°
3.0%
14.3%
9.4%
3.9%
98.4°
86.2°
86.2°
98.4°
8.7%
32.2%
10.6%
33.2%
3.1 NM
8810'
3.1 NM
7.5 NM
7.5 NM

Note 1. All turn radii = 1.5 NM

Note 2. Percentages designate weighted average flight track usage for takeoff or approach, as indicated by direction of arrows

Figure 3.2-5. AVport B Configuration

Note 1. All turn radii = 1.5 NM

Note 2. Percentages designate weighted average flight track usage for takeoff or approach, as indicated by direction of arrows

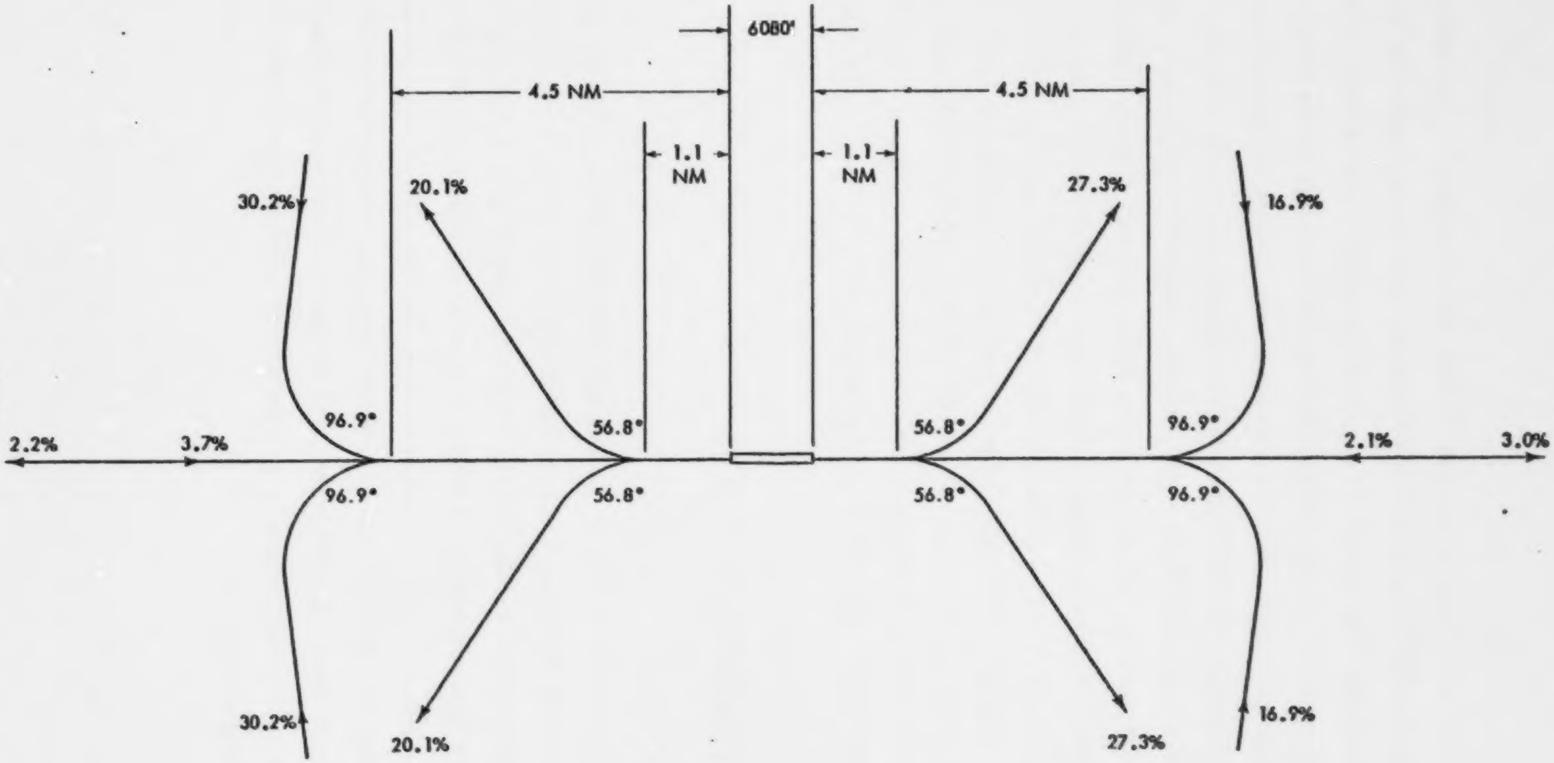

6080'
4.5 NM
4.5 NM
1.1 NM
1.1 NM
30.2%
20.1%
27.3%
16.9%
96.9°
56.8°
56.8°
96.9°
2.2%
3.7%
2.1%
3.0%
96.9°
56.8°
56.8°
96.9°
30.2%
20.1%
27.3%
16.9%

Figure 3.2-6. AVport C-1 and C-2 Configuration

or the left, which was in turn followed by another straight segment. The turning tracks were assumed to be symmetrical about the extended runway centerline for both takeoffs and landings. The decision to use three takeoff and landing tracks in each direction represents a compromise between placing all the flights on one track, thereby creating long thin noise contours, and alternatively, placing the flights on a large number of complex tracks, creating a more circular set of noise contours. In order to establish an average flight track geometry, weighted averages were calculated for the distance to the first turn in the flight track and also the angle of the first turn. These averages were based on flight track definition data for actual airports. The averages were taken for takeoffs and landings separately and for right and left turns separately. The results of these calculations are shown in Table 3.2-2 which illustrates that there is no major difference between the geometry of tracks turning right or those turning left, thus justifying the assumptions of symmetry. Figures 3.2-4, 3.2-5, and 3.2-6 present the final flight tracks used for AVports A, B, C-1 and C-2 in this study.

3.3 Projections of Aircraft Operations

3.3.1 Assumptions

In projecting the number of operations at each AVport for each study scenario, no attempt was made to project future air traffic explicitly for this study. Instead, recent FAA publications[1,2] were used as a basis for developing two overall growth scenarios which provided a range of operations levels that might occur through the year 2000. Of the many FAA forecasts available, the ones used in this study were selected because they provided detailed information on the retirement schedules of particular aircraft types. Growth in the level of operations was assumed to be accommodated by increasing capacity by expansion of existing airports rather than by newly constructed airports.

Table 3.2-2

Average Flight Track Dimensions

AVport A

Takeoff				Approach			
Distance *		Angle†		Distance		Angle	
Right	Left	Right	Left	Right	Left	Right	Left
2.2	2.9	73.8	73.5	10.9	9.3	101.4	90.3
2.6		73.6		10.1		95.8	

AVport B

Takeoff				Approach			
Distance *		Angle		Distance		Angle	
Right	Left	Right	Left	Right	Left	Right	Left
3.3	2.8	88.7	83.2	7.2	7.9	102.1	94.0
3.1		86.2		7.5		98.4	

AVport C-1 and C-2

Takeoff				Approach			
Distance *		Angle		Distance		Angle	
Right	Left	Right	Left	Right	Left	Right	Left
1.0	1.3	46.3	69.9	3.8	5.3	91.3	102.8
1.1		56.8		4.5		96.9	

* Distance from the end of the runway to the start of the first turn (nautical miles)

† Angle of first turn (degrees)

3.3.2 General Description of Method

The method used to establish the number of operations for each study scenario is outlined below.

- The projected number of each aircraft type in the aircarrier fleet was determined for each year and study option.
- Based on current fleet size and operations levels for each aircraft type,[5,6,24,25] the number of operations that a single aircraft can be expected to perform during a year was computed.
- For each year, the projected number of aircraft was multiplied by the number of operations that can be expected for each aircraft type. The product of this multiplication is the estimated annual number of operations for each aircraft type.
- These projected national operations were distributed to the AVports based on the relative mix of current operations at all the airports in each AVport class.
- The day/night and trip length distributions for each aircraft type was defined based on current operations at the sample airports.

3.3.3 Details of the Operations Projections

Aircarrier Fleet Definition

The starting point in preparing the operations forecasts was to develop two alternative fleet forecasts for 5-year increments through the year 2000. One projection was to be representative of a moderate growth in operations and the other projection was to be representative of expansive growth that might occur under the best of circumstances favoring unlimited growth in aircarrier operations. The moderate growth fleet forecast was based entirely on the FAR (Federal Aviation Regulation) Part 36 Environmental Impact Statement, Case 3.[1] The fleet size for the expansive growth scenario was taken from the FAA publication, Aviation Futures Through the Year 2000, Scenario 5, Expansive Growth.[2]

The aircraft types that were chosen for this study as being representative of all types in service are listed in Table 3.3-1 along with the annual operations expected for each aircraft type. Propeller aircraft were excluded from the analysis because the noise levels they produce are usually insignificant at any airport that has even a small number of jet operations. Business jets, helicopters, and military aircraft were also excluded from the analysis.

New aircraft introduced into the fleet between 1975 and 1980, inclusive, were assumed to be production models of existing designs and, as such, were assumed to comply with the 69 FAR 36 noise rule.* Aircraft introduced into the fleet after 1980 were assumed to be newly designed aircraft or derivatives of existing aircraft types and, as such, were assumed to comply with the noise rule assumed to be in effect at the time of the original type design. A detailed example of this concept is presented later in this section.

Basic Fleet Size Projections

For the moderate growth scenario, the fleet size through 1995 was given in Reference 1. The year 2000 fleet was established by extrapolating the 1990 and 1995 results on a linear basis. The Reference 1 fleet projections indicate that by 1995, 74 percent of the aircraft that were in the fleet in 1975 were assumed to have been retired. By 2000, 92 percent of the aircraft in service in 1975 were assumed to have been retired. The new technology aircraft shown in Reference 2 were assumed to be new technology 3-engine aircraft. A more detailed description of the fleet projection method is presented in Appendix B.

For the expansive growth scenario, the gross numbers of aircraft in each category were taken from Reference 2, Scenario 5. These source data had to be

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*An exception was made for the 2-engine Narrow Body (see Appendix B).

Table 3.3-1

Aircraft/Operations Relationships for CY 1975

Aircraft Type	Estimated Annual Operations at U.S. Aircarrier Airports(6)	Aircarrier Jet Aircraft in Service(5)	Aircraft Productivity Factor*
Wide Body:			
4-engine	123,379	96	1,285
2-/3-engine	464,985	204	2,279
Narrow Body:			
4-engine	1,065,635	622	1,713
3-engine	3,225,564	790	4,083
2-engine	3,389,325	528	6,419
TOTAL	8,268,888	2,240	
New Technologies:			
3-engine Narrow Body	-	-	4,083**
Jet STOL	-	-	6,419**
4-engine Wide Body (1000 Pax)	-	-	1,285**

*Number of Annual Operations Performed by a Single Aircraft

$$= \frac{\text{(Operations)}}{\text{(Number of Aircraft)}}$$

**Based on Operations/Aircraft for Existing Aircraft adjusted, however, because the categories were not defined in sufficient detail for this study. For example, in Reference 2, 2- and 3-engine aircraft were combined into one category and no distinction was made between complying and noncomplying aircraft. The additional infomation needed for this fleet breakdown was derived from the relative percentages of aircraft categories given in Reference 1. A more detailed description of the methods used to develop the fleet projections for the expansive growth scenario is also presented in Appendix B.

FAR Part 36 Compliance

In addition to specifying the number of each general aircraft type, the number of aircraft had to be further categorized as either meeting or not meeting 1969 FAR Part 36 noise requirements. The FAR Part 36 EIS was used as a basis for this distribution since each aircraft category in the EIS was divided into three categories: aircraft that currently comply (meet 1969 FAR Part 36), aircraft that do not comply, and aircraft that have been modified to comply. For this study, it was assumed that the "do not comply" and "modified to comply" categories represent those aircraft in the fleet in 1975 that did not comply (with 1969 FAR Part 36). For expansive growth, a detailed breakdown of the number of aircraft that meet 1969 FAR Part 36 in each year was not available. Consequently, the number of "1975" aircraft in each year for the expansive growth was assumed to be the same as the number of "1975" aircraft in the moderate growth case.

Introduction of New Aircraft

As mentioned earlier, all aircraft produced after 1980 were assumed to be new types or derivatives of existing designs which meet the appropriate noise rules. It was assumed that all of these aircraft would remain in the fleet through the year 2000. Thus, any increase in number of aircraft in the fleet from one year to the next, as indicated in References 1 and 2, was attributed to the production of new aircraft during the interim period. The question still remained as to which of these aircraft were produced according to each of the proposed noise rules. The following scenario was assumed to resolve this question.

- Three aircraft designs (either new or derivative) – X, Y, and Z – were assumed to account for all new aircraft.
- X always accounts for aircraft that meet the 1975 rules; Y accounts for aircraft that meet the proposed 1980 rule; and Z accounts for aircraft that meet the proposed 1985 rule.
- In the first period that a new or derivative aircraft type is produced, X comprises all of the aircraft. In the next interim period, X comprises one-half of that period's production, and Y accounts for the rest. In the third production period, X, Y, and Z each comprise one-third of that period's production. This distribution remains constant for all subsequent production years.

This scenario provided for introduction of new and derivative aircraft in compliance with increasingly stringent noise rules while permitting older designs to remain in production through the year 2000.

The number of aircraft in the U.S. aircarrier fleet for each aircraft type and technology level are tabulated by year and level of growth (moderate or expansive) in Tables 3.3-2 and 3.3-3. All aircraft shown in the rows labeled "Wide Body 4-engine 1000 Passenger," "Narrow Body 3-engine (New Technology)," and "STOL 150 Passenger" are assumed to be new types of aircraft while the numbers shown in the remaining rows are actual and derivative designs of the aircraft type indicated by the respective row labels. Only the "Narrow Body 3-engine (New Technology)" new type design was considered for the moderate growth scenario while all three new type aircraft were assumed for the expansive growth fleet.

Figure 3.3-1 illustrates an example of the distribution of technology levels (i.e., noise rule applications) for the 4-engine Wide Body aircraft, and derivative designs, assuming the moderate growth fleet (Table 3.3-2) from 1975 through the year 2000. As can be seen in the figure, the growth in the number of aircraft from 1975 through 1980 is assumed to be new production of the existing aircraft design and, as such, the aircraft are required to meet the 69 FAR 36 rule. The growth from 1980 through 1985, on the other hand, is assumed to be new production models of a derivative of the existing aircraft which would comply with the 75 FAR 36 rule.* It can be seen that the growth of this particular derivative design continues through the year 2000. The growth from 1985 through 1990 is assumed to be new production models of two derivative designs, one mentioned just previously, labeled X, and a newer one labeled Y. The newer design, Y, is required to comply with the 80 FAR 36 proposed rule, if it is in effect (Technology Level 2). Otherwise, the 75 FAR 36 rule applies (Technology Level 1). It can be seen from Table 3.3-2 that half of the new aircraft are attributed to X and the other half to Y. The growth from 1990 through 1995 is assumed to be new production of three derivative designs, the two just mentioned and a third labeled Z. The derivative labeled Z is required to comply with the 85 FAR 36 proposed rule if it is in effect (Technology Level 3). Otherwise, the 80 FAR 36 proposed rule or the 75 FAR 36 rule applies, whichever is in effect. This new growth in aircraft as well as the growth from 1995 through 2000 is apportioned equally between the X, Y, and Z derivative designs.

Aircraft Productivity

In order to translate the number of aircraft in the fleet into the number of annual operations, an aircraft productivity factor was developed for each aircraft type. This factor was simply the ratio for the number of operations performed in 1975 by each aircraft type to the number of aircraft of each type in service in that year. The number of aircraft in the fleet was obtained from Reference 5 and the number of operations performed by each aircraft during the year was obtained from References 6, 24 and 25. The resulting productivity factor for each aircraft type was shown earlier in Table 3.3-1.

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*It was assumed that the new type certification was applied for 6 years prior to actual production and thus it appears as a 10-year time lag for the compliance regulation since the fleet estimates are based on 5-year intervals.

Table 3.3-2

Number of Aircraft in Fleet
Moderate Growth

Aircraft Type	Technology	YEAR					
		1975	1980	1985	1990	1995	2000
Wide Body 4-engine 1000 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	—	—	—	—	—	—
	Total	—	—	—	—	—	—
Wide Body 4-engine	1969 Rule	51	85	85	85	59	34
	1975 Rule	—	—	70	105	172	239
	1980 Rule	—	—	—	35	102	169
	1985 Rule	—	—	—	—	67	133
	Noncomply	45	45	45 *	45 *	45*	45 *
	Total	96	130	200	270	445	620
Wide Body 2-/3-engine	1969 Rule	204	264	264	264	162	60
	1975 Rule	—	—	157	241	375	509
	1980 Rule	—	—	—	83	217	351
	1985 Rule	—	—	—	—	134	268
	Noncomply	—	—	—	—	—	—
	Total	204	264	421	588	888	1,188
Narrow Body 4-engine	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	622	454	98 *	—	—	—
	Total	622	454	98	—	—	—
Narrow Body 3-engine	1969 Rule	218	381	381	381	272	163
	1975 Rule	—	—	21	31	38	75
	1980 Rule	—	—	—	10	17	53
	1985 Rule	—	—	—	—	7	43
	Noncomply	572	500	397 *	293 *	8 *	0
	Total	790	881	799	715	342	334
Narrow Body 3-engine (New Technology)	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	367	443	531	590
	1980 Rule	—	—	—	75	163	222
	1985 Rule	—	—	—	—	88	146
	Noncomply	—	—	—	—	—	—
	Total	—	—	367	518	782	958
Narrow Body 2-engine	1969 Rule	48	278	278	278	254	230
	1975 Rule	—	25	185	282	444	605
	1980 Rule	—	—	160	258	419	560
	1985 Rule	—	—	—	98	259	421
	Noncomply	480	463	426 *	399 *	269 *	139 *
	Total	528	766	1,049	1,315	1,645	1,975
STOL 150 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	—	—	—	—	—	—
	Total	—	—	—	—	—	—
	TOTAL	2,240	2,[illegible]5	2,934	3,406	4,102	5,075

* Modified to comply with the 69 FAR 36 rule.

Table 3.3-3

Number of Aircraft in Fleet

Expansive Growth

Aircraft Type	Technology	YEAR					
		1975	1980	1985	1990	1995	2000
Wide Body 4-engine 1000 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	39	68	96	137
	1980 Rule	—	—	—	30	58	99
	1985 Rule	—	—	—	—	29	71
	Noncomply	—	—	—	—	—	—
	Total	—	—	39	98	183	307
Wide Body 4-engine	1969 Rule	51	180	180	180	154	129
	1975 Rule	—	—	125	194	244	304
	1980 Rule	—	—	—	69	119	179
	1985 Rule	—	—	—	—	50	110
	Noncomply	45	45	45 *	45 *	45 *	45 *
	Total	96	225	350	488	612	767
Wide Body 2-/3-engine	1969 Rule	204	290	290	290	188	86
	1975 Rule	—	—	177	310	447	646
	1980 Rule	—	—	—	132	269	468
	1985 Rule	—	—	—	—	136	334
	Noncomply	—	—	—	—	—	—
	Total	204	290	467	732	1,040	1,534
Narrow Body 4-engine	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	622	454	98 *	—	—	—
	Total	622	454	98	—	—	—
Narrow Body 3-engine	1969 Rule	218	387	387	387	278	169
	1975 Rule	—	—	24	35	43	68
	1980 Rule	—	—	—	12	20	45
	1985 Rule	—	—	—	—	8	33
	Noncomply	572	500	397 *	293 *	8 *	0
	Total	790	887	808	727	357	315
Narrow Body 3-engine (New Technology)	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	277	370	428	485
	1980 Rule	—	—	—	94	153	211
	1985 Rule	—	—	—	—	59	117
	Noncomply	—	—	—	—	—	—
	Total	—	—	277	464	640	813
Narrow Body 2-engine	1969 Rule	48	283	283	283	259	235
	1975 Rule	—	25	108	217	437	544
	1980 Rule	—	—	82	191	411	519
	1985 Rule	—	—	—	109	329	437
	Noncomply	480	463	426 *	399 *	269 *	139 *
	Total	528	771	899	1,199	1,705	1,874
STOL 150 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	39	166	273	401
	1980 Rule	—	—	—	127	233	361
	1985 Rule	—	—	—	—	106	235
	Noncomply	—	—	—	—	—	—
	Total	—	—	39	293	612	997
	TOTAL	2,240	2,627	2,977	4,001	5,149	6,607

* Modified to comply with the 69 FAR 36 rule.

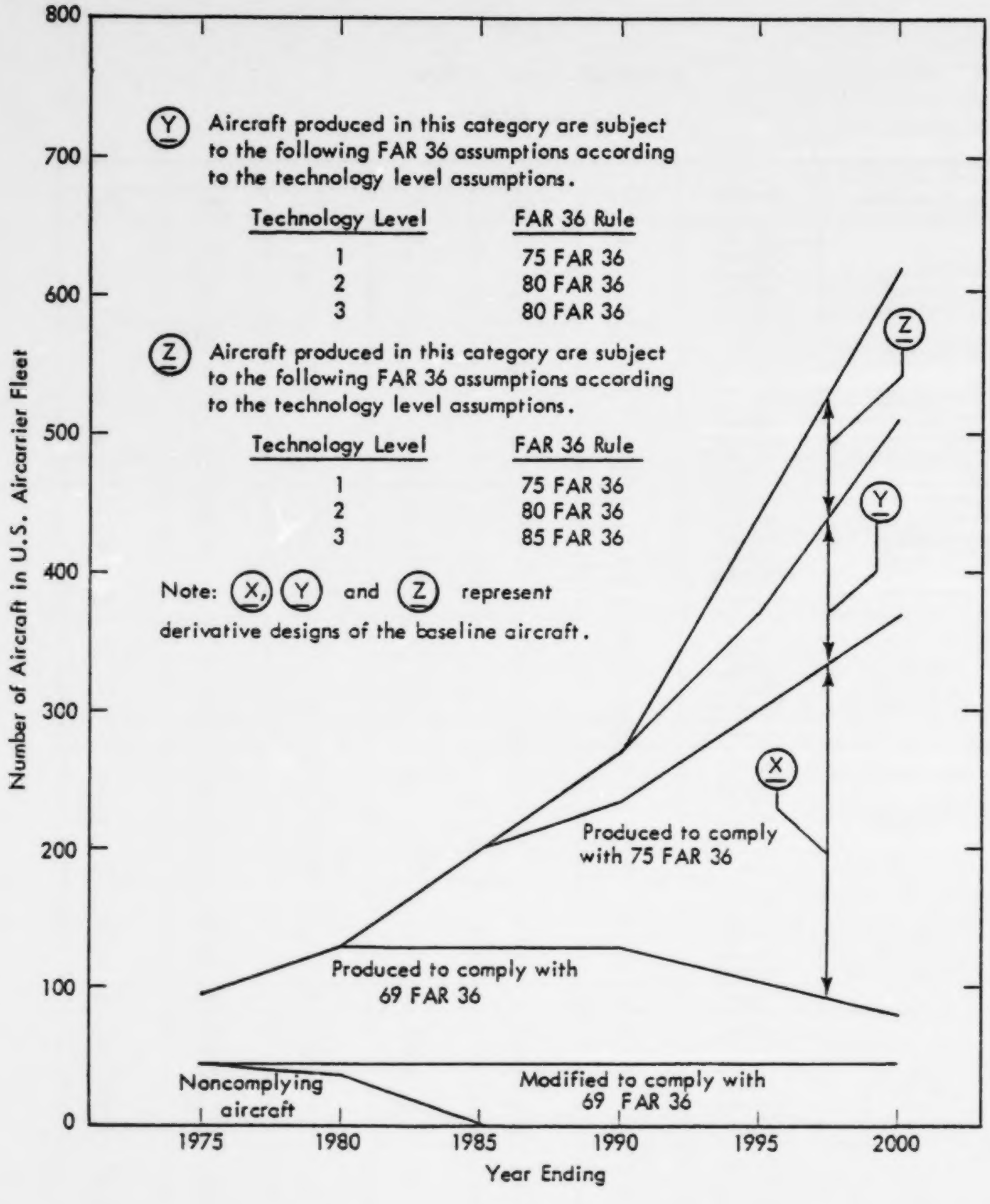


Figure 3.3-1. Example of Distribution and Total Number of 4-engine Wide Body Aircraft in the U.S. Aircarrier Fleet Through the Year 2000 Assuming the Moderate Growth Scenario

Annual Operations for Each Aircraft Type

Using the productivity factors just described, the total number of annual operations performed by each aircraft type was estimated for each of the two growth scenarios by multiplying the appropriate productivity factor by the assumed number of aircraft in the fleet, shown in Tables 3.3-2 and 3.3-3, for each of the scenarios. The results showing annual operations are tabulated in Tables 3.3-4 and 3.3-5.

Assignment of Annual Operations to AVports

The percentage of annual operations of each aircraft type at each AVport was estimated by examining the operations at each airport in each AVport class for the year 1975.[6,24,25] First, the number of operations of each type of aircraft were estimated for each airport. Next, the total number of operations for each aircraft type was computed for each AVport class by summing the operations from all of the individual airports in each AVport class. Finally, each aircraft type in each AVport class was assigned a percentage value in proportion to the number of operations estimated. It should be noted that 0.2 percent of the 2-engine Narrow Body jet operations were assigned to "other" airports. These airports are those with less than 20 jet operations per year and were excluded from this analysis. These percentages are tabulated in Table 3.3-6.

Distribution of Trip Lengths and Day/Night Operations

The last step in developing the AVport operations was to provide a percentage distribution of the number of aircraft operations in the daytime period (0700-2200) and nighttime period (2200-0700), and to develop an estimate of the percentage distribution of trip lengths for each aircraft type. This was done in a straightforward fashion based on the relative numbers of day and night operations[8,17,18] for each stage length at the sample airports in each AVport category. These distributions are shown in Tables 3.3-7, 3.3-8 and 3.3-9.

Table 3.3-4

Annual Aircarrier Jet Operations
Moderate Growth

Aircraft Type	Technology	YEAR					
		1975	1980	1985	1990	1995	2000
Wide Body 4-engine 1000 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	—	—	—	—	—	—
	Total	—	—	—	—	—	—
Wide Body 4-engine	1969 Rule	65,545	109,242	109,242	109,242	75,827	43,697
	1975 Rule	—	—	89,964	134,946	221,054	307,162
	1980 Rule	—	—	—	44,982	131,090	217,098
	1985 Rule	—	—	—	—	86,108	170,931
	Noncomply	57,834	57,834	57,834*	57,834*	57,834*	57,834*
	Total	123,379	167,076	257,040	347,004	571,913	796,822
Wide Body 2-/3-engine	1969 Rule	464,985	601,745	601,745	601,745	369,253	136,760
	1975 Rule	—	—	357,856	549,321	854,752	1,160,183
	1980 Rule	—	—	—	189,185	494,616	800,048
	1985 Rule	—	—	—	—	305,431	610,863
	Noncomply	—	—	—	—	—	—
	Total	464,985	601,745	959,601	1,340,251	2,024,052	2,707,854
Narrow Body 4-engine	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	1,065,635	777,811	167,897*	—	—	—
	Total	1,065,636	777,311	167,897	—	—	—
Narrow Body 3-engine	1969 Rule	890,092	1,555,620	1,555,620	1,555,620	1,110,574	665,528
	1975 Rule	—	—	85,743	126,573	155,154	306,224
	1980 Rule	—	—	—	40,830	69,411	216,399
	1985 Rule	—	—	—	—	28,581	175,569
	Noncomply	2,335,472	2,041,496	1,620,948*	1,198,317*	32,664*	—
	Total	3,225,564	3,597,116	3,262,311	2,919,340	1,396,384	1,363,720
Narrow Body 3-engine (New Technology)	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	1,498,458	1,808,766	2,168,069	2,408,966
	1980 Rule	—	—	—	306,224	665,528	906,424
	1985 Rule	—	—	—	—	359,303	596,117
	Noncomply	—	—	—	—	—	—
	Total	—	—	1,498,458	2,114,990	3,192,900	3,911,507
Narrow Body 2-engine	1969 Rule	308,120	1,784,531	1,784,531	1,784,531	1,630,471	1,476,411
	1975 Rule	—	160,479	1,187,548	1,810,208	2,850,114	3,883,602
	1980 Rule	—	—	1,027,068	1,656,417	2,689,635	3,723,122
	1985 Rule	—	—	—	629,079	1,662,567	2,702,473
	Noncomply	3,081,205	2,972,079	2,734,569*	2,561,251*	1,726,758*	592,265*
	Total	3,389,325	4,917,089	6,733,716	8,441,216	10,559,545	12,577,873
STOL 150 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	—	—	—	—	—	—
	Total	—	—	—	—	—	—
	TOTAL	8,268,888	10,060,837	12,379,023	15,162,801	17,744,794	21,457,776

*

Aircraft were modified to comply with the 69 FAR 36 rule.

Table 3.3-5

Annual Aircarrier Jet Operations
Expansive Growth

Aircraft Type	Technology	YEAR					
		1975	1980	1985	1990	1995	2000
Wide Body 4-engine 1000 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	50,123	87,393	123,379	176,072
	1980 Rule	—	—	—	38,556	74,541	127,235
	1985 Rule	—	—	—	—	37,271	91,249
	Noncomply	—	—	—	—	—	—
	Total	—	—	50,123	125,949	235,191	394,556
Wide Body 4-engine	1969 Rule	65,545	231,336	231,336	231,336	197,920	165,791
	1975 Rule	—	—	160,650	249,328	313,588	390,700
	1980 Rule	—	—	—	88,679	152,939	230,050
	1985 Rule	—	—	—	—	64,260	141,372
	Noncomply	57,834	57,834	57,834*	57,834*	57,834*	57,834*
	Total	123,379	289,170	449,820	627,177	786,541	985,747
Wide Body 2-/3-engine	1969 Rule	464,985	661,008	661,008	661,008	428,516	196,023
	1975 Rule	—	—	403,443	706,595	1,018,864	1,472,452
	1980 Rule	—	—	—	300,873	613,142	1,066,730
	1985 Rule	—	—	—	—	309,990	761,299
	Noncomply	—	—	—	—	—	—
	Total	464,985	661,008	1,064,451	1,668,476	2,370,512	3,496,504
Narrow Body 4-engine	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	—	—	—	—
	1980 Rule	—	—	—	—	—	—
	1985 Rule	—	—	—	—	—	—
	Noncomply	1,065,635	777,811	167,897*	—	—	—
	Total	1,065,635	777,811	167,897	—	—	—
Narrow Body 3-engine	1969 Rule	890,092	1,580,118	1,580,118	1,580,118	1,135,072	690,026
	1975 Rule	—	—	97,992	142,905	175,569	277,643
	1980 Rule	—	—	—	48,996	81,660	183,735
	1985 Rule	—	—	—	—	32,664	134,739
	Noncomply	2,335,472	2,041,496	1,620,948*	1,196,317*	32,664*	—
	Total	3,225,564	3,621,614	3,299,058	2,968,336	1,457,629	1,286,143
Narrow Body 3-engine (New Technology)	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	1,130,989	1,510,707	1,747,521	1,980,251
	1980 Rule	—	—	—	383,801	624,698	861,511
	1985 Rule	—	—	—	—	240,897	477,710
	Noncomply	—	—	—	—	—	—
	Total	—	—	1,130,989	1,894,508	2,613,116	3,319,472
Narrow Body 2-engine	1969 Rule	308,120	1,816,627	1,816,627	1,816,627	1,662,567	1,508,506
	1975 Rule	—	160,479	693,271	1,392,961	2,805,180	3,492,032
	1980 Rule	—	—	526,372	1,226,063	2,638,281	3,331,552
	1985 Rule	—	—	—	699,690	2,111,909	2,805,180
	Noncomply	3,081,205	2,972,079	2,734,569*	2,561,251*	1,726,758*	892,265*
	Total	3,389,325	4,949,185	5,770,839	7,696,592	10,944,695	12,029,535
STOL 150 Passenger	1969 Rule	—	—	—	—	—	—
	1975 Rule	—	—	250,348	1,065,583	1,752,435	2,574,090
	1980 Rule	—	—	—	815,235	1,495,668	2,317,323
	1985 Rule	—	—	—	—	680,433	1,508,506
	Noncomply	—	—	—	—	—	—
	Total	—	—	250,348	1,880,818	3,928,536	6,399,919
	TOTAL	8,268,888	10,298,788	12,183,525	16,861,856	22,336,220	27,911,876

* Aircraft were modified to comply with the 69 FAR 36 rule.

Table 3.3-6

Percent of National Operations in Each AVport Category

Aircraft Type	AVport Category				
	A	B	C-1	C-2	Others
Wide Body:					
4-engine	88.8	11.2	–	–	–
2-/3-engine	57.1	41.5	1.3	0.1	–
Narrow Body:					
4-engine	56.3	43.7	–	–	–
3-engine	31.9	57.1	7.4	3.6	–
2-engine	17.5	56.9	3.9	21.5	0.2
New Technologies:*					
3-engine Narrow Body	31.9	57.1	7.4	3.6	–
Jet STOL (150 Passenger)	17.5	56.9	3.9	21.5	0.2
4-engine Wide Body (1000 Passenger)	88.8	11.2	–	–	–

*Based on distributions for aircraft in the existing fleet flying similar missions.

Table 3.3-7

Fraction of Aircraft Takeoffs and Landings in Each Trip Length Category AVPORT A

Aircraft Type	Time*	Trip Length (Nautical Miles)							
		LDGS	0 500	500 1000	1000 1500	1500 2500	2500 3500	3500 4500	4500 +
Wide Body									
4-engine (1000 Pax)	D	0.859	0.033	0.054	0.105	0.329	0.166	0.115	0.058
	N	0.141	0.007	0.015	0.065	0.014	0.022	0.011	0.006
4-engine	D	0.859	0.033	0.054	0.105	0.329	0.166	0.115	0.058
	N	0.141	0.007	0.015	0.065	0.014	0.022	0.011	0.006
2-/3-engine	D	0.828	0.100	0.173	0.130	0.336	0.074	0.009	0.007
	N	0.172	0.021	0.041	0.063	0.038	0.005	0.001	0.002
Narrow Body									
4-engine	D	0.745	0.215	0.160	0.063	0.204	0.050	0.050	0.009
	N	0.255	0.074	0.042	0.009	0.085	0.028	0.011	0
3-engine (New Tech)	D	0.877	0.541	0.153	0.170	0.014	0	0	0
	N	0.123	0.064	0.034	0.020	0.004	0	0	0
3-engine	D	0.877	0.541	0.153	0.170	0.014	0	0	0
	N	0.123	0.064	0.034	0.020	0.004	0	0	0
2-engine	D	0.910	0.715	0.175	0.019	0.001	0	0	0
	N	0.090	0.062	0.026	0.002	0	0	0	0
STOL									
150 Passenger	D	0.910	0.715	0.175	0.019	0.001	0	0	0
	N	0.090	0.062	0.026	0.002	0	0	0	0

* D designates daytime period (0700–2200 hrs), N designated nighttime period (2200–0700 hrs).

Table 3.3-8

Fraction of Aircraft Takeoffs and Landings in Each Trip Length Category AVPORT B

Aircraft Type	Time	Trip Length (Nautical Miles)							
		LDGS	0 500	500 1000	1000 1500	1500 2500	2500 3500	3500 4500	4500 +
Wide Body									
4-engine (1000 Pax)	D	0.824	0.525	0.001	0.275	0.006	0	0	0.004
	N	0.176	0.103	0.000	0.084	0.001	0	0	0.001
4-engine	D	0.824	0.525	0.001	0.275	0.006	0	0	0.004
	N	0.176	0.103	0.000	0.084	0.001	0	0	0.001
2-/3-engine	D	0.734	0.265	0.431	0	0.038	0	0	0.001
	N	0.266	0.015	0.250	0	0	0	0	0
Narrow Body									
4-engine	D	0.808	0.337	0.269	0.131	0.071	0.006	0	0
	N	0.192	0.081	0.045	0.036	0.014	0.010	0	0
3-engine (New Tech.)	D	0.885	0.585	0.237	0.041	0.023	0	0	0
	N	0.115	0.073	0.027	0.011	0.003	0	0	0
3-engine	D	0.885	0.585	0.237	0.041	0.023	0	0	0
	N	0.115	0.073	0.027	0.011	0.003	0	0	0
2-engine	D	0.890	0.760	0.123	0.002	0.005	0	0	0
	N	0.110	0.093	0.014	0.002	0.001	0	0	0
STOL									
150 Passenger	D	0.890	0.760	0.123	0.002	0.005	0	0	0
	N	0.110	0.093	0.014	0.002	0.001	0	0	0

Table 3.3-9

Fraction of Aircraft Takeoffs and Landings in Each Trip Length Category AVPORT C-1 and C-2

Aircraft Type	Time	Trip Length (Nautical Miles)							
		LDGS	0 500	500 1000	1000 1500	1500 2500	2500 3500	3500 4500	4500 +
Wide Body									
4-engine (1000 Pax)	D	0	0	0	0	0	0	0	0
	N	0	0	0	0	0	0	0	0
4-engine	D	0	0	0	0	0	0	0	0
	N		0	0		0	0	0	0
2-/3-engine	D	.975	.631	.246	.098	0	0	0	0
	N	.025	0	.025	0	0	0	0	0
Narrow Body									
4-engine	D	0	0	0	0	0	0	0	0
	N	0	0	0	0	0	0	0	0
3-engine (New Tech)	D	.950	.570	.307	.073	0	0	0	0
	N	.050	.025	.014	.011	0	0	0	0
3-engine	D	.950	.570	.307	.073	0	0	0	0
	N	.050	.025	.014	.011	0	0	0	0
2-engine	D	.960	.766	.194	.003	0	0	0	0
	N	.040	.034	.003	0	0	0	0	0
STOL									
150 Passenger	D	.960	.766	.194	.003	0	0	0	0
	N	.040	.034	.003	0	0	0	0	0

Estimating Operations on the Busiest AVport Runway

Since each of the model airports used for analysis in this study consisted of only one runway, it was not always reasonable to place all the operations assigned to the average airport on the single runway. For example, AVport A represents the larger airports in the country, most of which have more than one runway. To place all the airport operations on one runway would result in unrealistic noise contours. This potential difficulty was overcome by using the average number of operations on the busiest runway for the sample airports in each category to model the noise exposure at the AVport. The results obtained from this busy-runway analysis were then scaled up to reflect the impact due to all operations at the average airport. By using this busy-runway concept, it was possible to limit the number of operations on the model runway to a predetermined maximum which was defined by capacity restrictions for a single runway.[7]

The aircraft operations numbers for the AVports were found by multiplying the annual operations shown in Tables 3.3-4 and 3.3-5 by the percentages in Tables 3.3-6 and 3.3-7 through 3.3-9 and then dividing that by the number of airports in the AVport class. These AVport operations were then adjusted to reflect busy runway operations.

3.4 Noise Data

3.4.1 Regulatory Action

The regulatory actions pertinent to this study, given in chronological order, are as follows:

1. On 18 November 1969, the FAA published their basic rule, Federal Aviation Regulations Part 36 (identified herein as 69 FAR 36) on noise measurement and evaluation standards, compliance noise levels, and certification test procedures.

2. On 26 October 1973, FAA published a rule (Amendment 36-2) that newly produced airplanes of older type designs must comply with the noise level requirements of 69 FAR 36.

3. On 28 March 1975, the FAA published the EPA's proposed rule for Civil Supersonic Airplanes. Later production or derived versions of current SST types would be required to comply with 69 FAR 36. Future SST types would be obliged to meet the FAR 36 requirements in effect on the date of application of the type certificate.

4. On 12 February 1976, the FAA published the EPA's proposed rule which would require that no civil supersonic transport category airplane may operate from an airport in the United States unless that airplane complies with 69 FAR 36.

5. On 28 October 1976, the FAA published the EPA's recommendations for revisions to FAR 36 which would require noise reductions for new type design aircraft beginning in 1980 and again in 1985 (identified herein as 80 FAR 36 and 85 FAR 36, respectively).

6. On 23 December 1976, FAA published the new retrofit/replacement rule (Amendment 91-136) which would require all existing aircraft to comply with the 69 FAR 36 noise level requirements by the year 1985.

7. On 3 March 1977, the FAA published new requirements for FAR 36 (Amendment 36-7), the new compliance noise levels, applicable to new type design aircraft on or after 1975 (identified herein as 75 FAR 36). This action resulted from FAA NPRM 75-37 published 5 November 1975.

The noise level requirements for the different FAR 36 scenarios identified above are presented graphically in Figure 3.4-1 for the takeoff configuration and in Figure 3.4-2 for the landing configuration.

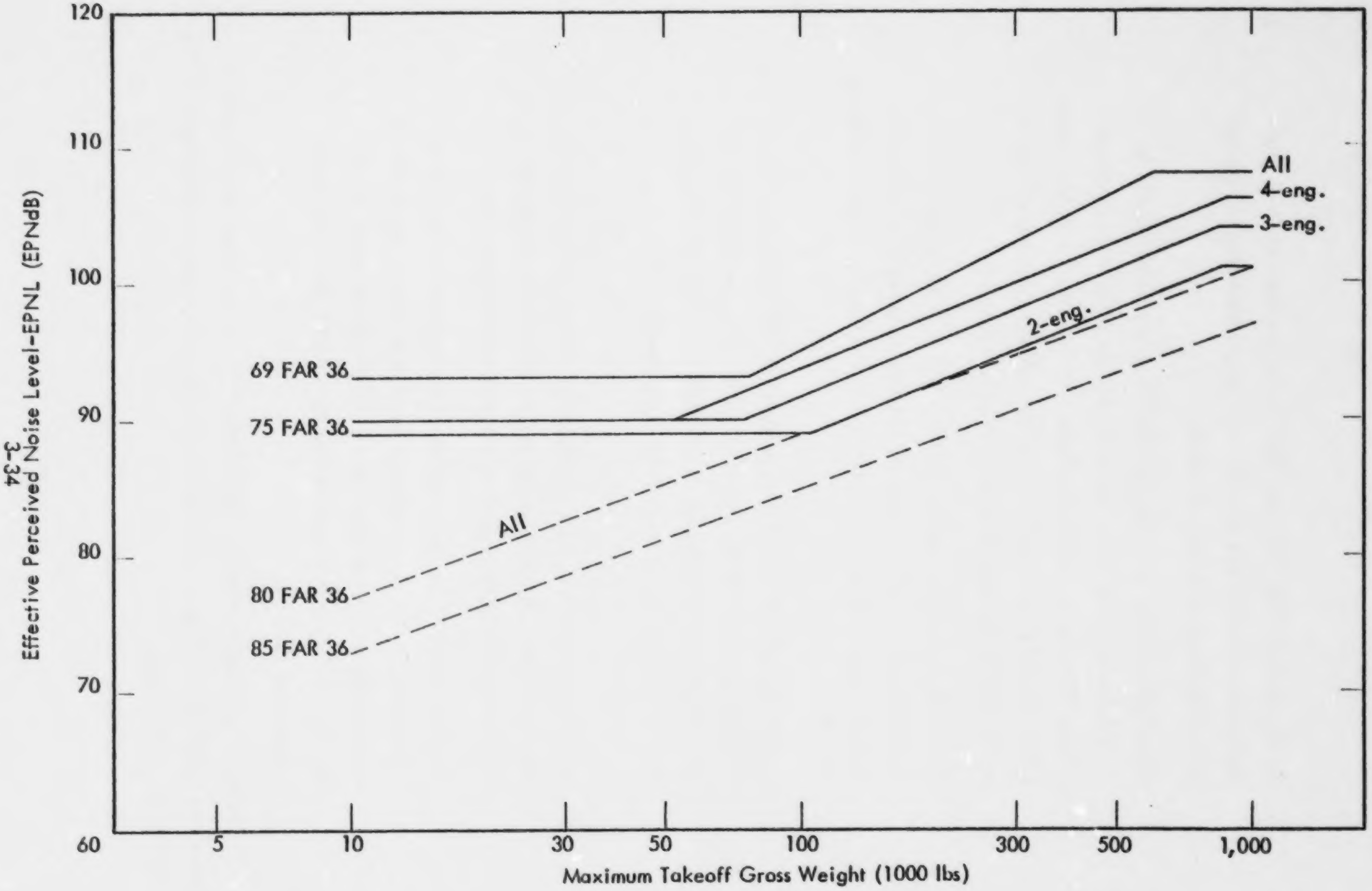


Figure 3.4-1. Comparison of the Four FAR 36 Noise Rules for Takeoff Certification.

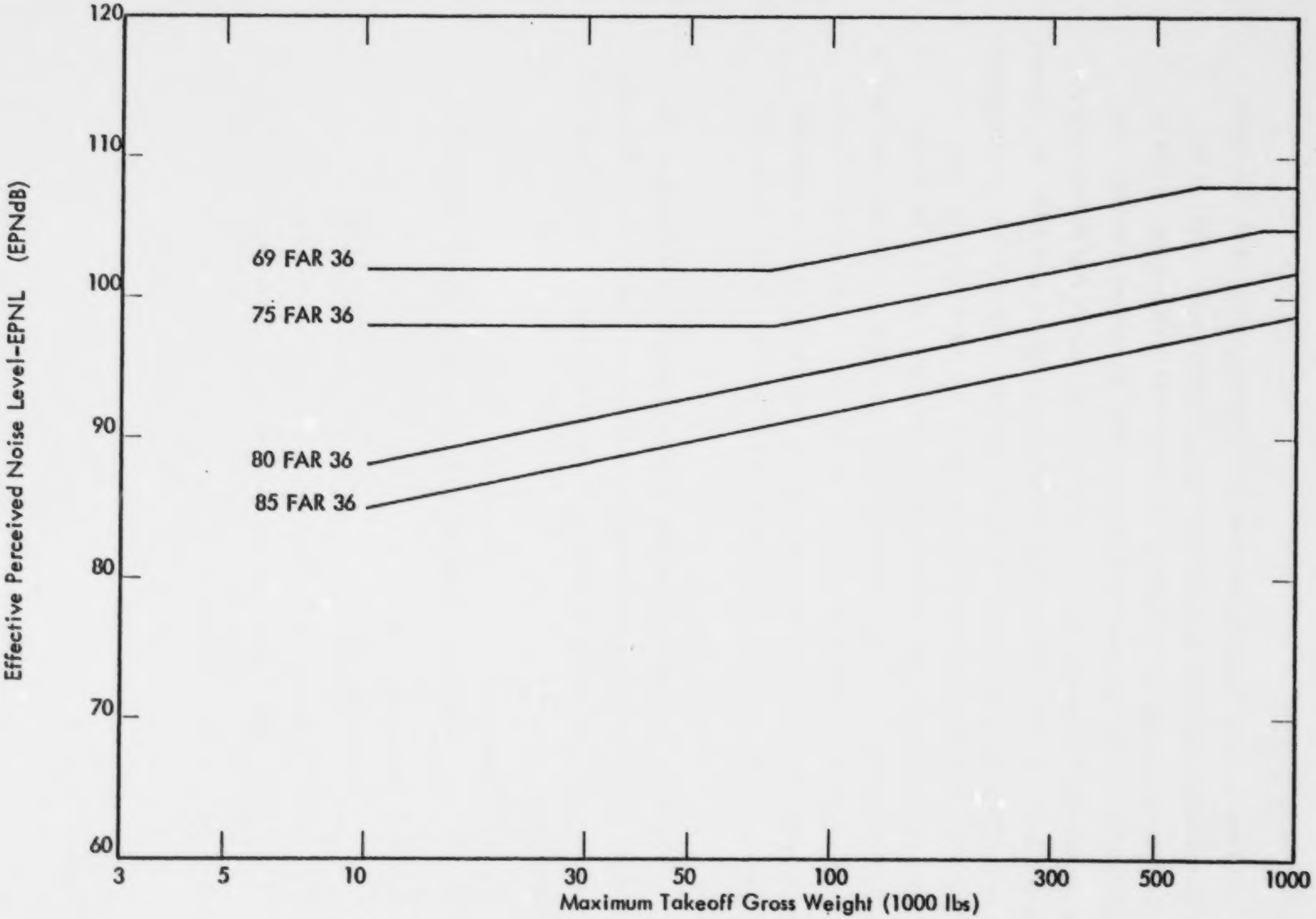


Figure 3.4-2. Comparison of the Four FAR 36 Noise Rules for Landing Certification.

3.4.2 Noise Scenarios

Three scenarios involving the time-phased implementation of the 80 FAR 36 and 85 FAR 36 proposed rules were examined as a part of this study. First, it was assumed that the proposed rules would not be implemented at all and that 75 FAR 36 would provide the noise requirements for future aircraft through the year 2000. This case was labeled "Technology Level 1." Second, it was assumed that 80 FAR 36 would become effective in 1980 and would remain in effect through the year 2000. This scenario was called "Technology Level 2." Finally, the third assumption was that both the proposed 80 FAR 36 and 85 FAR 36 rules would be promulgated thus requiring further noise reduction for new aircraft after 1985 through the year 2000. This case was labeled "Technology Level 3." An additional scenario was examined, "Technology Level 3A," in which all aircraft in the year 2000 were assumed to comply with 85 FAR 36. While it may not be realistic to assume that all aircraft will meet 85 FAR 36 in the year 2000, the case provides an indication of what might be achieved at some date farther into the future.

The following presents, in outline form, by technology level and year, the time-phase relationships of the four scenarios just discussed including the baseline case for the year 1975. The portion of the fleet to which each noise rule applies is defined for each year.

- Baseline
  - 1975 Only: Actual Levels (i.e., existing aircraft noise levels)
- Technology Level 1

•1980 Aircraft	Noise Levels
. Current FAR 36 Types:	Actual Levels
. 80% Current Non FAR 36 Types:	Actual Levels

    - 20% Current Non FAR 36 Types: 69 FAR 36 Levels *
    - New Types (Post 1975): 75 FAR 36 Levels
  - 1985-2000
    - Current FAR 36 Types: Actual Levels
    - Current Non FAR 36 Types: 69 FAR 36 Levels *
    - New Types (Post 1975): 75 FAR 36 Levels

- Technology Level 2
  - 1980 Aircraft   Noise Levels
    - Current FAR 36 Types: Actual Levels
    - 80% Current Non FAR 36 Types: Actual Levels
    - 20% Current Non FAR 36 Types: 69 FAR 36 Levels *
    - New Types (1975-1980): 75 FAR 36 Levels
  - 1985-2000
    - Current FAR 36 Types: Actual Levels
    - Current Non FAR 36 Types 69 FAR 36 Levels *
    - New Types (1975-1980): 75 FAR 36 Levels
    - New Types (Post 1980): 80 FAR 36 Levels

- Technology Level 3
  - 1980 Aircraft   Noise Levels
    - Current FAR 36 Types: Actual Levels
    - 80% Current Non FAR 36 Types: Actual Levels
    - 20% Current Non FAR 36 Types: 69 FAR 36 Levels *
    - New Types (1975-1980): 75 FAR 36 Levels

---

*Equivalent to application of FAR Amendment 91-136 (Retrofit Rule).

- 1985
    - Current FAR 36 Types: Actual Levels
    - Current Non FAR 36 Types: 69 FAR 36 Levels[*]
    - New Types (1975-1980): 75 FAR 36 Levels
    - New Types (1980-1985): 80 FAR 36 Levels
- 1990-2000
    - Current FAR 36 Types: Actual Levels
    - Current Non FAR 36 Types: 69 FAR 36 Levels[*]
    - New Types (1975-1980): 75 FAR 36 Levels
    - New Types (1980-1985): 80 FAR 36 Levels
    - New Types (Post 1985): 85 FAR 36 Levels

3.4.3 The Noise Metric

The aircraft noise data for this study are expressed as Effective Perceived Noise Levels (EPNL) to facilitate direct comparisons between aircraft noise levels and the FAR 36 requirements. The composite noise metric used to express the final results is the Day-Night Sound Level (L_{dn}) and is estimated according to the following formula:

$$L_{dn} \approx NEF + 35 \quad , \text{dB}$$

where

NEF = Noise Exposure Forecast

as defined in Reference 19. EPNL is the basic single event noise metric used in the computation of NEF.

The aircraft noise curves developed for this study are shown graphically in Appendix C.

---

[*] Equivalent to application of FAR Amendment 91-136 (Retrofit Rule).

3.4.4 Development of Aircraft Noise Characteristics

In order to estimate the effect of the previously described rules and their associated implementation schedules, it was necessary to develop noise data for the aircraft being considered. The aircraft consisted of five generic types as listed below:

- 2-engine Narrow Body
- 3-engine Narrow Body
- 4-engine Narrow Body
- 2-/3-engine Wide Body
- 4-engine Wide Body

The remainder of this section describes the method by which the noise level emission characteristics are estimated for future aircraft as well as for present aircraft required to comply with noise level regulations at some time in the future. Briefly, the method consists of systematically modifying the best available noise level information for existing aircraft to conform with future noise level regulations.

The first step is to obtain the best available data for the aircraft in question. Wherever possible, manufacturer's data are used to represent current conditions. Table 3.4-1 enumerates the presently operating aircraft which are representative of the above generic classes and identifies the aircraft chosen as a basis for the noise levels used in this study.

Table 3.4-1

Identification of Currently Operating Aircraft Whose Noise Characteristics were Assumed for Generic Aircraft Classes

Aircraft Class	Representative Aircraft	Noise Baseline
2-engine Narrow Body	737/DC-9	DC-9
3-engine Narrow Body	727	727
4-engine Narrow Body	707/DC-8	707
2-/3-engine Wide Body	A300B DC-10/L1011	DC-10
4-engine Wide Body	747	747

References 9, 10, 11, 12, 13

The noise characteristics for the aircraft identified in Table 3.4-1 were modified, using thrust interpolation, into five noise-thrust-distance curves for each aircraft and were considered to be the "baseline" or "actual" noise characteristics for each class. The thrust conditions for each of the five curves are listed below:

TOT – Takeoff Thrust
MCT – Maximum Climb Thrust
CBT – Cutback Thrust for ALPA/NWA Max. Cutback Procedure
APT – Approach Thrust
LDT – Landing Thrust

The second step is to determine whether "baseline" noise level data can be used as-is for future conditions or whether the existing data have to be modified first. To make this determination the FAR 36 certification levels for the takeoff and landing positions are compared to future requirements being considered. If the measured aircraft sound levels at the two certification positions are at or below the future certification requirements, the noise level curves are not modified. However, if the noise levels at the certification positions are above the future certification requirements, then the baseline noise level curves have to be adjusted. Table 3.4-2 quantifies the relationship between the "actual" noise levels, at the takeoff and landing certification positions, for the aircraft chosen to represent the classes shown in the table. Also given, are the adjustment factors which were used to modify the baseline noise levels to future conditions.

The third step is to develop adjusted noise level vs distance curves for future aircraft in the event that baseline data are not suitable. The baseline noise level versus distance data for the certification power conditions are compared to the future noise level certification requirements. The amount by which the current noise levels exceeded the future requirements is then subtracted from the baseline noise level vs distance curves at all distances. Adjustment for takeoff and landing noise level curves are not usually identical and are developed independently.

To adjust the baseline noise level vs distance curves for engine power conditions other than certification power conditions, a more complicated adjustment technique is used.

Figure 3.4-3 is provided to help illustrate this adjustment technique. Curves B_1, B_2, and B_3 represent the baseline noise curves and curves F_1, F_2, and F_3 represent the noise curves developed for future aircraft. Curves B_3, and F_3 represent noise curves

Table 3.4-2

Relationship of Baseline Noise Levels to 69 FAR 36 Requirements and Adjustment Factors for Compliance with Future Regulations

Aircraft Class	Max. TOGW (KLB)	Condition	1969 FAR 36 Limit (EPNdB)	Baseline Values (EPNdB)	Δ 69 FAR 36 (EPNdB)	Δ 75 FAR 36 (EPNdB)	Δ 80 FAR 36 (EPNdB)	Δ 85 FAR 36 (EPNdB)
2-eng. N.B.(1)	114	T/O	96.0	96.0	0	- 6.6	- 6.3	-10.3
		LDG	103.2	107.0	- 3.8	- 7.8	-11.6	-14.6
3-eng. N.B.(1)	190	T/O	99.0	101.2	- 2.2	- 5.8	- 8.9	-12.9
		LDG	104.4	108.2	- 3.8	- 7.5	-11.2	-14.2
4-eng. N.B.(1)	325	T/O	103.7	113.0	- 9.3	-12.5	-17.9	-21.9
		LDG	106.3	116.8	-10.5	-14.6	-18.2	-21.2
2-/3-eng. W.B.(2)	550	T/O	107.2	103.7	0	- 2.2	- 5.8	- 9.8
		LDG	107.7	103.0	0	0	- 2.8	- 5.8
4-eng. W.B.(2)	785	T/O	108.0	107.0	0	- 1.5	- 7.3	-11.3
		LDG	108.0	104.0	0	0	- 2.7	- 5.7

(1) Reference 1.

(2) Reference 14.

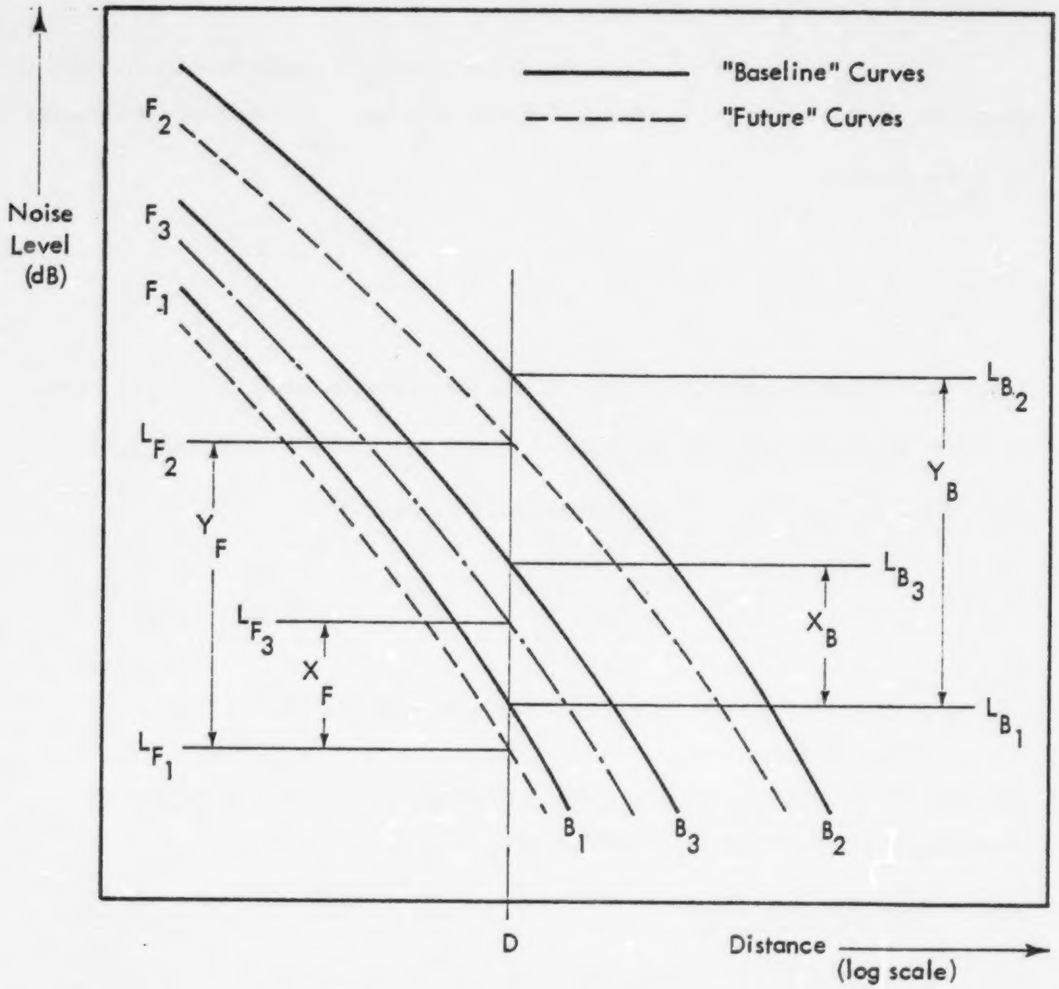

"Baseline" Curves
"Future" Curves
Noise Level (dB)
F_2
F_3
F_1
L_{F_2}
Y_F
L_{F_3}
X_F
L_{F_1}
L_{B_2}
Y_B
L_{B_3}
X_B
L_{B_1}
B_1
B_3
B_2
D
Distance
(log scale)

Figure 3.4-3. Schematic Illustration of Method for Adjusting Noise Level Curve

for power conditions not used during certification. Curves F_1 and F_2 represent noise curves for future aircraft at certification power conditions and are developed by shifting B_1, and B_2 as described previously.

Curve F_3 is the new noise level curve that ultimately results from the adjustment procedure. This curve is constructed as the locus of points L_{F_3} calculated for distances D, by the formula

$$L_{F_3} = \left(\frac{X_B}{Y_B}\right) (Y_F) + L_{F_1} \qquad (3.4\text{-}1)$$

This equation expresses mathematically that the position of curve F_3 relative to curves F_1 and F_2 should be similar to the position of curve B_3 relative to curves B_1 and B_2. Note that since $L_{F_3} = L_{F_1} + X_F$, equation (3.4-1) reduces to

$$\frac{X_F}{Y_F} = \frac{X_B}{Y_B} \qquad (3.4\text{-}2)$$

This equation shows the proportional relationship between the relative positions of the set of baseline curves and the relative positions of the set of derived curves. Equation 3.4-1 is equally valid for use in estimating data for future aircraft at all power conditions as long as X_B is defined as $L_{B_3} - L_{B_1}$.

3.5 Aircraft Performance

3.5.1 Aircraft Performance Scenarios

Four combinations of three different takeoff procedures and three different landing procedures were used for this study. These procedures are defined as follows and will be described in the following section.

- Baseline (1975 Only)
  - Departures: AC91-39 (Figure 1 of Reference 15)
  - Arrivals: 1500 ft. Intercept, 3-deg. Angle, Max. Flaps
- Procedure Level 1
  - Departures: AC91-39 (Figure 1 of Reference 15)
  - Arrivals: 1500 ft. Intercept, 3-deg. Angle, Min. Flaps
- Procedure Level 2
  - Departures: ALPA/NWA Max. Cutback (Figure 2 of Reference 15)
  - Arrivals: 3000 ft. Intercept, 3-deg. Angle, Min. Flaps
- Procedure Level 2A
  - Departures: ALPA/NWA Min. Cutback (Figure 5 of Reference 15)
  - Arrivals: 3000 ft. Intercept, 3-deg. Angle, Min. Flaps

3.5.2 Description of Aircraft Operating Procedures

Takeoff

The following paragraphs describe the "AC91-39" takeoff procedure (Baseline and Procedure Level 1) illustrated in Figure 3.5-1. This procedure, defined generally in Reference 27, is adopted, for this study, from the interpretation in Reference 15.

FIRST SEGMENT (ROLL & INITIAL CLIMB)

OAB	Brake release; takeoff roll with takeoff thrust (TOT); rotate and climb to 35-ft. height above airport (HAA); and accelerate to V2 keas.*
BB'	Retract gear; climb to 400 ft HAA; and accelerate to V2 + 10 (+) keas.

---

* knots equivalent air speed

(+) indicates speed acceleration beyond V2 + 10 keas if pitch attitude limited, or to enable a lesser flap setting during second segment, or if approved for practical or safety reasons.

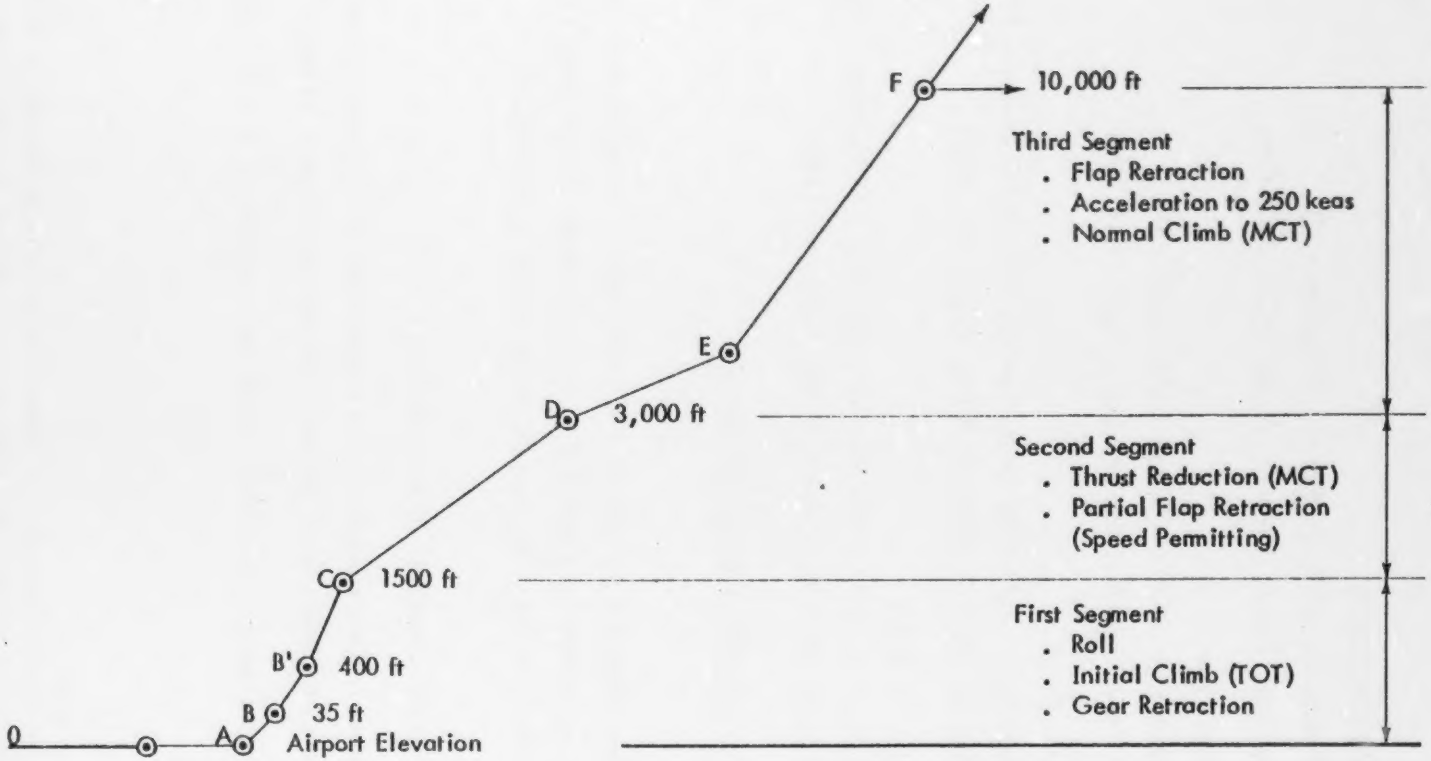

F
10,000 ft
E
D
3,000 ft
C
1500 ft
B'
400 ft
B
35 ft
A
Airport Elevation
0
Third Segment
. Flap Retraction
. Acceleration to 250 keas
. Normal Climb (MCT)
Second Segment
. Thrust Reduction (MCT)
. Partial Flap Retraction
(Speed Permitting)
First Segment
. Roll
. Initial Climb (TOT)
. Gear Retraction

Figure 3.5-1. AC91-39 Flight Profile Illustration

B'C Climb to 1500 ft HAA with:

- Thrust = TOT,
- Speed = V2 + 10 (+) keas,
- Flaps = takeoff,
- Gear = retracted.

SECOND SEGMENT (THRUST CUTBACK)

C At 1500 ft HAA, maintain speed, reduce thrust to maximum climb thrust (MCT), and perform partial flap retraction if speed permits.

CD Climb to 3000 ft HAA with:

- Thrust = MCT,
- Speed = V2 + 10 (+) keas,
- Flaps = takeoff or partial retraction if speed permits,
- Gear = retracted.

THIRD SEGMENT (NORMAL CLIMB)

D At 3000 ft HAA, maintain MCT, retract remaining flaps per flap retraction schedule, and accelerate to 250 keas with 500 to 1000 fpm rate of climb.

DE Climb and accelerate to 250 keas with:

- Thrust = MCT,
- Speed = V2 + 10 (+) to 250 keas,
- Flaps = retract,
- Gear = retracted.

E When a speed of 250 keas and flap retraction are achieved, maintain MCT and initiate normal climb schedule.

EF Climb to 10,000 ft HAA with:

- Thrust = MCT,
- Speed = 250 keas,
- Flaps = retracted,
- Gear = retracted.

(+) indicates speed acceleration beyond V2 + 10 keas if pitch attitude limited, or to enable a lesser flap setting during second segment, or if approved for practical or safety reasons.

F At 10000 ft HAA, continue climb at 250 keas or reduce thrust and proceed in horizontal flight at 250 keas.

The following paragraphs describe the ALPA/NWA Max. Cutback takeoff procedure* (Procedure Level 2) illustrated in Figure 3.5-2.

FIRST SEGMENT (ROLL & INITIAL CLIMB)

OAB Brake release; takeoff roll with takeoff thrust (TOT); rotate and climb to 35 ft height above airport (HAA); and accelerate to V2 keas.

BB' Retract gear; climb to 400 ft HAA; and accelerate to V2 + 10 keas.

B'C Climb to 1000 ft HAA with:

- Thrust = TOT,
- Speed = V2 + 10 keas (or greater if approved),
- Flaps = takeoff,
- Gear = retracted.

SECOND SEGMENT (THRUST CUTBACK)

C At 1000 ft HAA lower nose and accelerate to zero flaps speed (VZF), retract flaps per schedule, maintain TOT and a pitch attitude within 1/2 initial value plus 0 to 3 degrees and a rate of climb not less than 500 fpm.

CC' Climb and accelerate to VZF with:

- Thrust = TOT,
- Speed = V2 + 10 to VZF keas,
- Flaps = retract,
- Gear = retracted.

C' When a speed of VZF and flap retraction are achieved, reduce thrust to the greater cutback thrust (CBT) that will give a rate of climb of 1000 fpm or the following positive climb gradients if one engine should become inoperative:

---

*ALPA/NWA Max. Cutback refers to a composite of power cutback procedures proposed by the Air Line Pilots Association (ALPA) and Northwest Airlines (NWA) and interpreted in Reference 15.

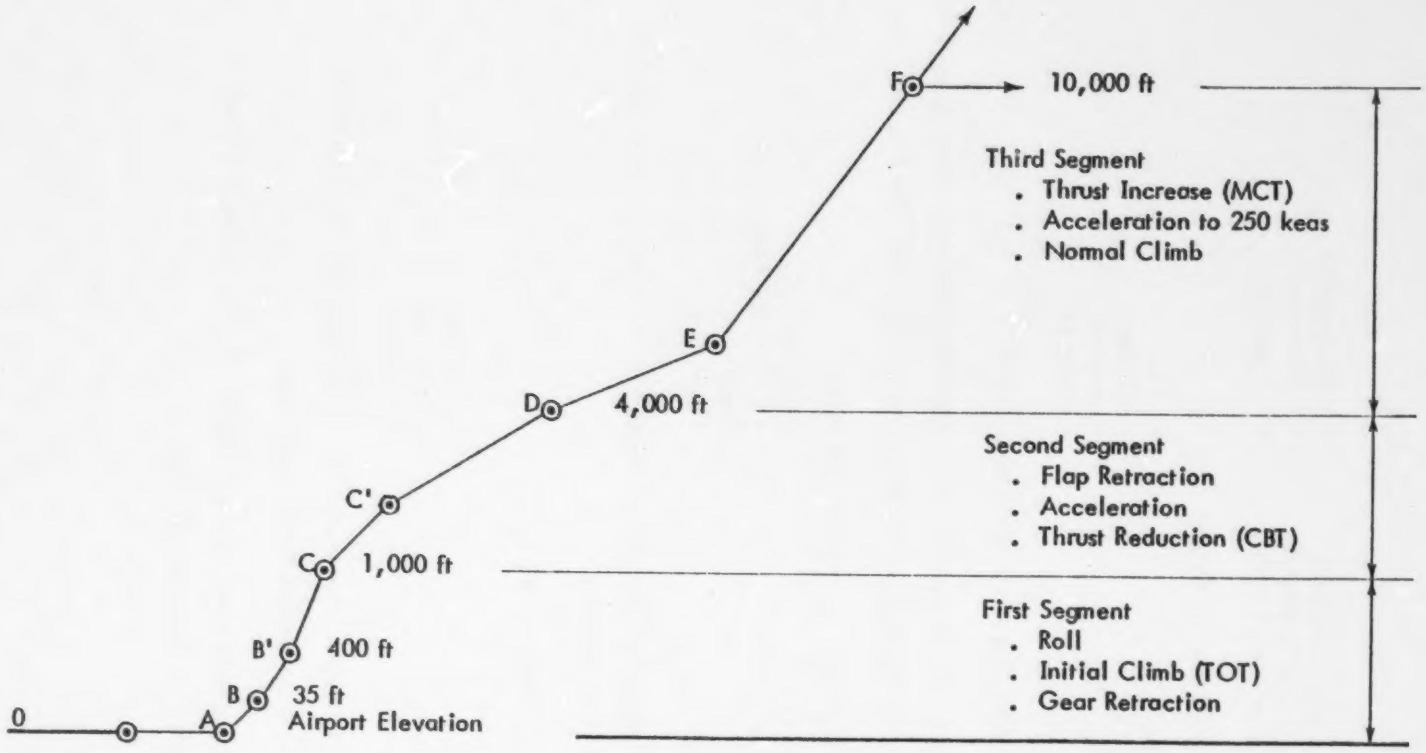

F
10,000 ft
Third Segment
. Thrust Increase (MCT)
. Acceleration to 250 keas
. Normal Climb
E
D
4,000 ft
Second Segment
. Flap Retraction
. Acceleration
. Thrust Reduction (CBT)
C'
C
1,000 ft
First Segment
. Roll
. Initial Climb (TOT)
. Gear Retraction
B'
400 ft
B
35 ft
0
A
Airport Elevation

Figure 3.5-2. ALPA/NWA Max. Cutback Flight Profile Illustration

- Two engine aircraft = 1.2 percent,
- Three engine aircraft = 1.5 percent,
- Four engine aircraft = 1.7 percent.

C'D Climb to 4000 ft HAA with:

- Thrust = CBT,
- Speed = VZF keas,
- Flaps = retracted,
- Gear = retracted.

THIRD SEGMENT (NORMAL CLIMB)

D At 4000 ft HAA, gradually increase thrust to maximum climb thrust (MCT), and accelerate to 250 keas with 500 to 1000 fpm rate of climb.

DE Climb and accelerate to 250 keas with:

- Thrust = CBT to MCT,
- Speed = VZF to 250 keas,
- Flaps = retracted,
- Gear = retracted.

E When a speed of 250 keas and a thrust of MCT are achieved, initiate normal climb schedule.

EF Climb to 10000 ft HAA with:

- Thrust = MCT,
- Speed = 250 keas,
- Flaps = retracted,
- Gear = retracted.

F At 10000 ft HAA, continue climb at 250 keas or reduce thrust and proceed in horizontal flight at 250 keas.

The following paragraphs describe the ALPA/NWA Min. Cutback takeoff procedure (Procedure Level 2A) illustrated in Figure 3.5-3.

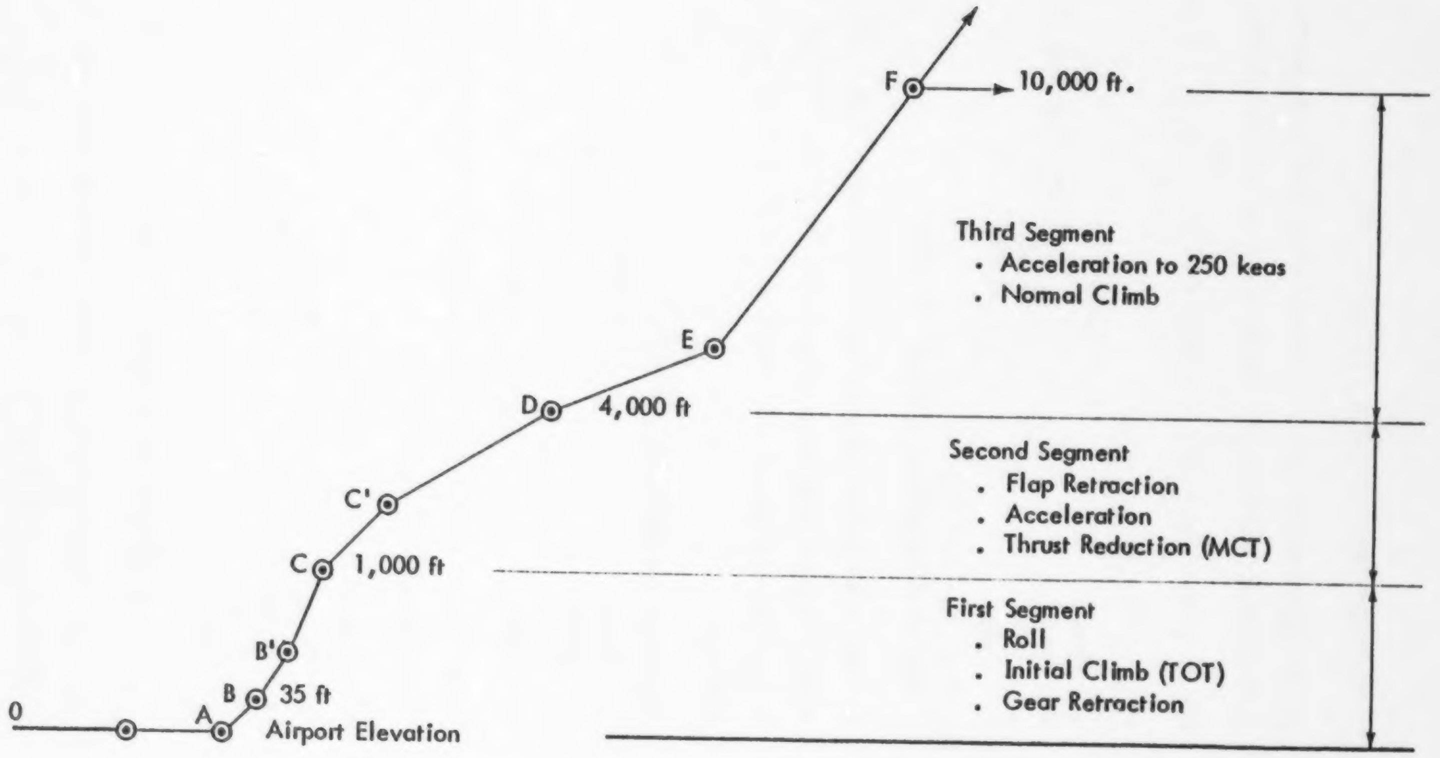

F
10,000 ft.
Third Segment
. Acceleration to 250 keas
. Normal Climb
E
D
4,000 ft
Second Segment
. Flap Retraction
. Acceleration
. Thrust Reduction (MCT)
C'
C
1,000 ft
First Segment
. Roll
. Initial Climb (TOT)
. Gear Retraction
B'
B
35 ft
0
A
Airport Elevation

Figure 3.5-3. ALPA/NWA Min. Cutback Flight Profile Illustration

FIRST SEGMENT (ROLL & INITIAL CLIMB)

OAB Brake release; takeoff roll with takeoff thrust (TOT); rotate and climb to 35 ft height above airport (HAA); and accelerate to V2 keas.

BB' Retract gear; climb to 400 ft HAA; and accelerate to V2 + 10 keas.

B'C Climb to 1000 ft HAA with:

- Thrust = TOT,
- Speed = V2 + 10 keas (or greater if approved)
- Flaps = takeoff,
- Gear = retracted.

SECOND SEGMENT (THRUST CUTBACK)

C At 1000 ft HAA, lower nose and accelerate to zero flaps speed (VZF), retract flaps per schedule, maintain TOT and a pitch attitude within 1/2 initial value plus 0 to 3 degrees and a rate of climb not less than 500 fpm.

CC' Climb and accelerate to VZF with:

- Thrust = TOT,
- Speed = V2 + 10 to VZF keas,
- Flaps = retract,
- Gear = retracted.

C' When a speed of VZF and flap retraction are achieved, reduce thrust to maximum climb thrust (MCT).

C'D Climb to 4000 ft HAA with:

- Thrust = MCT,
- Speed = VZF keas,
- Flaps = retracted,
- Gear = retracted.

THIRD SEGMENT (NORMAL CLIMB)

D At 4000 ft HAA, maintain MCT and accelerate to 250 keas with 500 to 1000 fpm rate of climb.

DE Climb and accelerate to 250 keas with:

- Thrust = MCT,
- Speed = VZF to 250 keas,
- Flaps = retracted,
- Gear = retracted.

E When a normal speed of 250 keas and a thrust of MCT are achieved, initiate normal climb schedule.

EF Climb to 10000 ft HAA with:

- Thrust = MCT,
- Speed = 250 keas,
- Flaps = retracted,
- Gear = retracted.

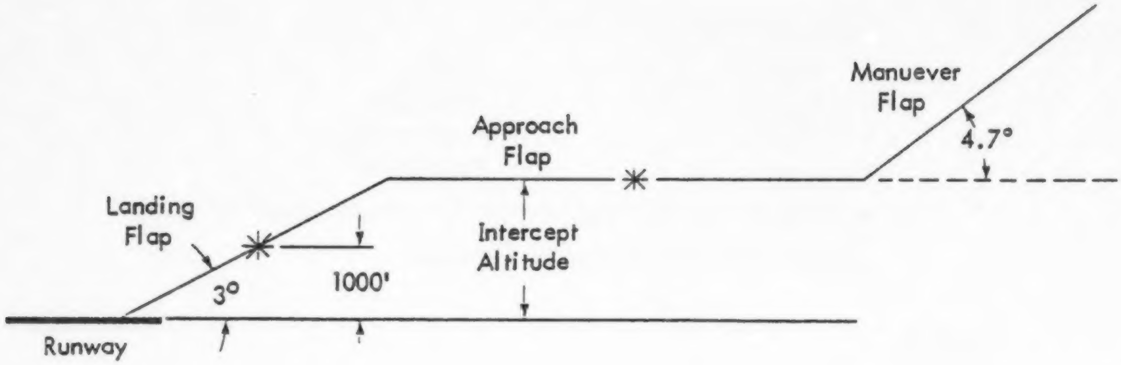
F At 10000 ft HAA continue climb at 250 keas or reduce thrust and proceed in horizontal flight at 250 keas.

Landing

The following paragraphs describe the parameters mentioned in the previous definition of the three landing procedures used in this study.

- 1500 ft and 3000 ft Intercept refers to the height above the airport at which the descent along the final glideslope is initiated.
- 3-deg. refers to the final glideslope angle.
- Min. and Max. Flap refer to minimum and maximum certified flap settings for landing configuration for the aircraft involved.

For this study, all landing operations were handled, conceptually, in the same manner. Figure 3.5-4 graphically illustrates the procedures used. Briefly, the aircraft descend from some higher altitude to the intercept altitude at a 500 ft/nautical mile ($\approx -4.7°$) rate and flaps set to "maneuver" position. Level flight is maintained at the intercept altitude until the final glideslope is intercepted. Prior to intercepting the final glideslope, flaps are extended to the "approach" position. Descent along the final glideslope is begun at the point of intersection with the intercept altitude. At 1000 feet above airport level the flaps are extended to the full "landing" position. The descent along the glideslope is maintained until touchdown.


Manuever
Flap
4.7°
Approach
Flap
Landing
Flap
Intercept
Altitude
3°
1000'
Runway

✳ Flap Transition Points

Figure 3.5-4. Typical Landing Profile Used for All Aircraft at All AVports

3.5.3 Development of Aircraft Performance Data

The primary sources of data on aircraft performance were References 9, 10, 11, 12, and 13. The computational procedures used to compute the specific flight performance definitions were derived from References 20 and 21. The following paragraphs discuss the computational procedures used and are followed by specific discussions for each of the departure and landing scenarios. Table 3.5-1 identifies the specific aircraft whose flight characteristics were used as representative of each aircraft classification.

Table 3.5-1

Representative Aircraft for Performance Baseline

Aircraft Class	Performance Baseline
2-engine Narrow Body	737/DC-9
3-engine Narrow Body	727
4-engine Narrow Body	DC-8
2-/3-engine Wide Body	DC-10
4-engine Wide Body	747

Computational Methods

Where calculations of aircraft aerodynamic performance were required, the following formula was used:

$$\frac{T}{W} - \frac{D}{L} \cos \theta - \frac{1.69}{g} \frac{dV}{dt} = \sin \theta$$

where

T = Total Net Thrust , lbs

W = Aircraft Weight , lbs

D/L = Drag to Lift Ratio

V = Velocity	, knots
g = Acceleration of gravity	, ft/sec^2
θ = Climb Angle	, radians

Aircraft Performance Data

For the AC91-39 takeoff procedure (Procedure Level 1) the performance data contained within the Wyle Integrated Noise Model computer program were used (this program is discussed in Section 3.8). Using the above equation, the performance characteristics for the ALPA/NWA Max. Cutback and ALPA/NWA Min. Cutback procedures (Procedure Levels 2 and 2A, respectively) were derived from the performance data contained in the Wyle Integrated Noise Model (INM).

Appendix D contains graphical descriptions of the aircraft takeoff performance data used for this study.

Table 3.5-2 describes the landing parameters generated for maximum and minimum flap settings used in this study, and defines the assumed flap settings for each aircraft category.

Table 3.5-2

Landing Parameters Assumed for Each Aircraft Class

Aircraft Class	Landing Weight (KLB)	Landing Velocity (KTS) Max/Min	THRUST					FLAPS		
			(LF) -3° Max/Min	(AF) 0° Max/Min	(AF) -3° Max/Min	(MF) 0° Max/Min	(MF) -4.7° Max/Min	LF (deg) Max/Min	AF (deg) Max/Min	MF (deg) Max/Min
2-eng. N.B.	88	133/141	4825/2430	4930/3706	2640/1400	4820/4820	1220/1220	40/25	25/15	5/5
3-eng. N.B.	138	132/138	6000/3300	5000/4164	2590/1750	3130/3130	500/500	40/25	25/15	5/5
4-eng. N.B.	190	135/135	3885/2650	4790/4689	2365/2200	3980/3980	700/700	40/25	30/25	14/14
2-/3-eng. W.B.	300	138/	8535/	11000/	5760/	9800/	1800/	35/35	18/18	5/5
4-eng. W.B.	500	146/157	11800/7150	14950/11550	8400/5000	11380/11360	2790/2790	30/20	25/20	10/10

Notes:

Thrust given in net pounds per engine.

Max/Min refers to flap settings.

LF - Landing Flap (final flap setting before touchdown).

AF - Approach Flap (Intermediate flap setting).

MF - Maneuver Flap (Initial flap setting at start of approach procedures).

3.6 Population Model

3.6.1 General Description of Procedure

The objective of the population analysis was to estimate the number of people exposed to various noise levels across the nation as a result of aircarrier aircraft activity. The procedure used to prepare this estimate was to utilize empirically derived regression equations relating total impacted population to total contour area at the AVports. These regression equations, based on available data from previous studies,[3, 8, 17, 18] provided an estimate of the number of people exposed to the noise levels of interest at each AVport. This AVport estimate was then scaled up to provide an estimate of the national exposure. The details of this method are discussed in this section.

3.6.2 Details of the Population Exposure Calculation Method

The estimated trend in average population density at airports within various size classes was known from 1970 U.S. Census information obtained for a previous study.[3] These data showed that the population density around airports tended to vary systematically as a function of distance from the center of the airport and the size of the airport based on number of daily aircarrier aircraft operations. This trend, illustrated in Figure 3.6-1, is based on the population data around 165 of the nation's largest aircarrier airports across the country. The data showed that there was no consistent pattern in the population density distribution as a function of angle relative to the main ILS runway but that there was a definite pattern in the population density distribution as a function of radial distance from the center of the runway. However, when these population distribution data were transformed into a generalized model, the results proved to be inconsistent with other data which provided a more direct relationship between known population within a given contour and the contour area. Thus, it was these later data which formed the primary base for the population model utilized in this study.

Specific data were available from References 8, 17 and 18 on total exposed population versus total contour area for 100 percent of the airports within AVport A category, 10 percent of the airports within AVport B category, and 100 percent of the

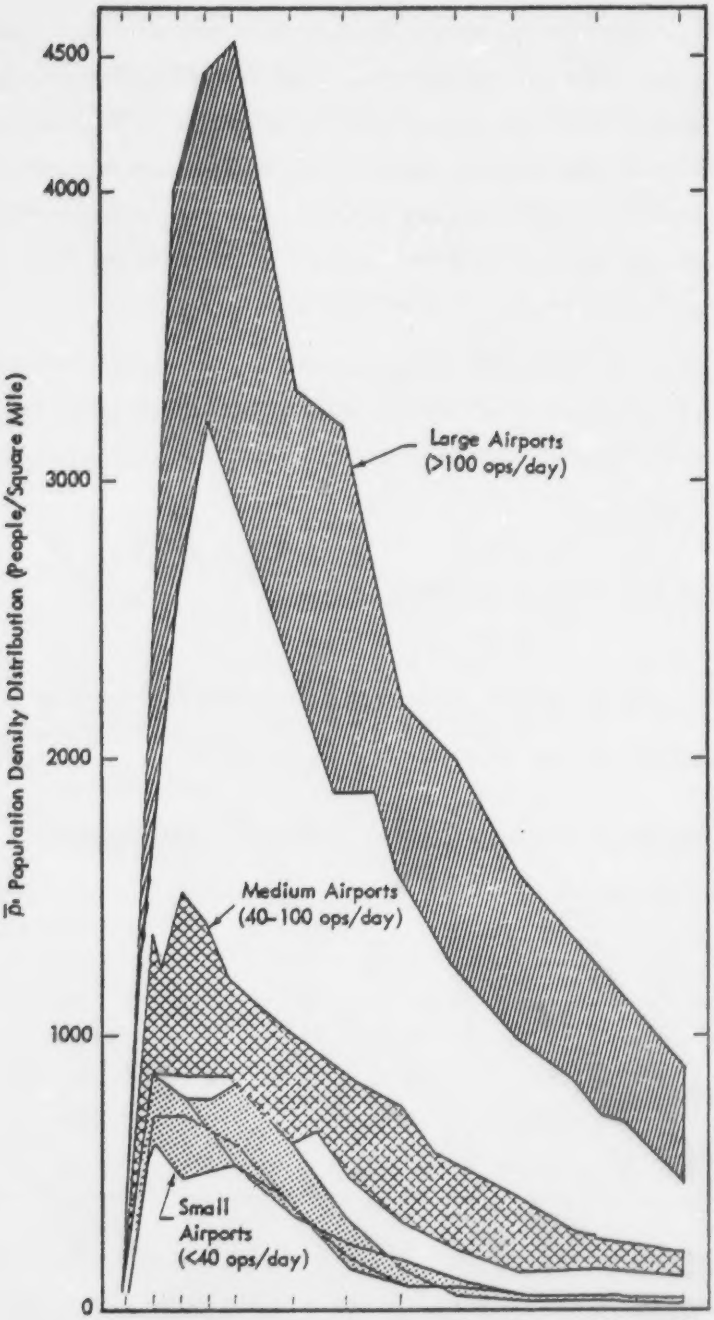


Figure 3.6-1. Population Density Distribution for Aircarrier Airports as a Function of Daily Aircarrier Operations (Reference 3)

airports within AVport C-1 category. While specific data on exposed population versus contour area were not available for AVport category C-2 airports (airports without 4-engine turbojet operations excluding La Guardia or Washington National), an estimated relationship between population and contour area had been developed in a previous study[3] for airports with approximately the same average number (21) of daily aircarrier operations as for AVport C-2 (17.9 operations per day). Thus, the relationship developed for that study was utilized here.

The resulting four relationships between population and contour area are illustrated in Figure 3.6-2 along with the available data upon which they were based. The four resulting curves were defined by one consistent type of nonlinear regression equation as follows:

$$\text{Total Airport Population (1000's)} = 10^{(a_0 + a_1 x + a_2 x^2 + a_3 x^3)} \qquad (3.6\text{-}1)$$

where

$$x = \log\,(\text{Total AVport or "Average Airport" Contour Area, mi}^2)$$

and the regression constants have the following values for the four different AVports.

Regression Constants Relating Contour Area and Population

AVport	Airport Sample (%)	a_0	a_1	a_2	a_3
A	13 (100%)	-2.560	6.975	-4.140	0.9726
B	11 (10%)	-0.3313	2.494	-0.9767	0.2099
C-1	2 (100%)	-0.9224	3,279	-0.7978	0.2127
C-2	(from Ref. 3)	-0.5997	2.063	-0.9654	0.2822

The regression equations for AVports A, B, and C-1 are based on the arithmetic average areas and populations for the sample airports included in the AVport category. The specific airports included in the population data base sample for AVports A, B and C-1

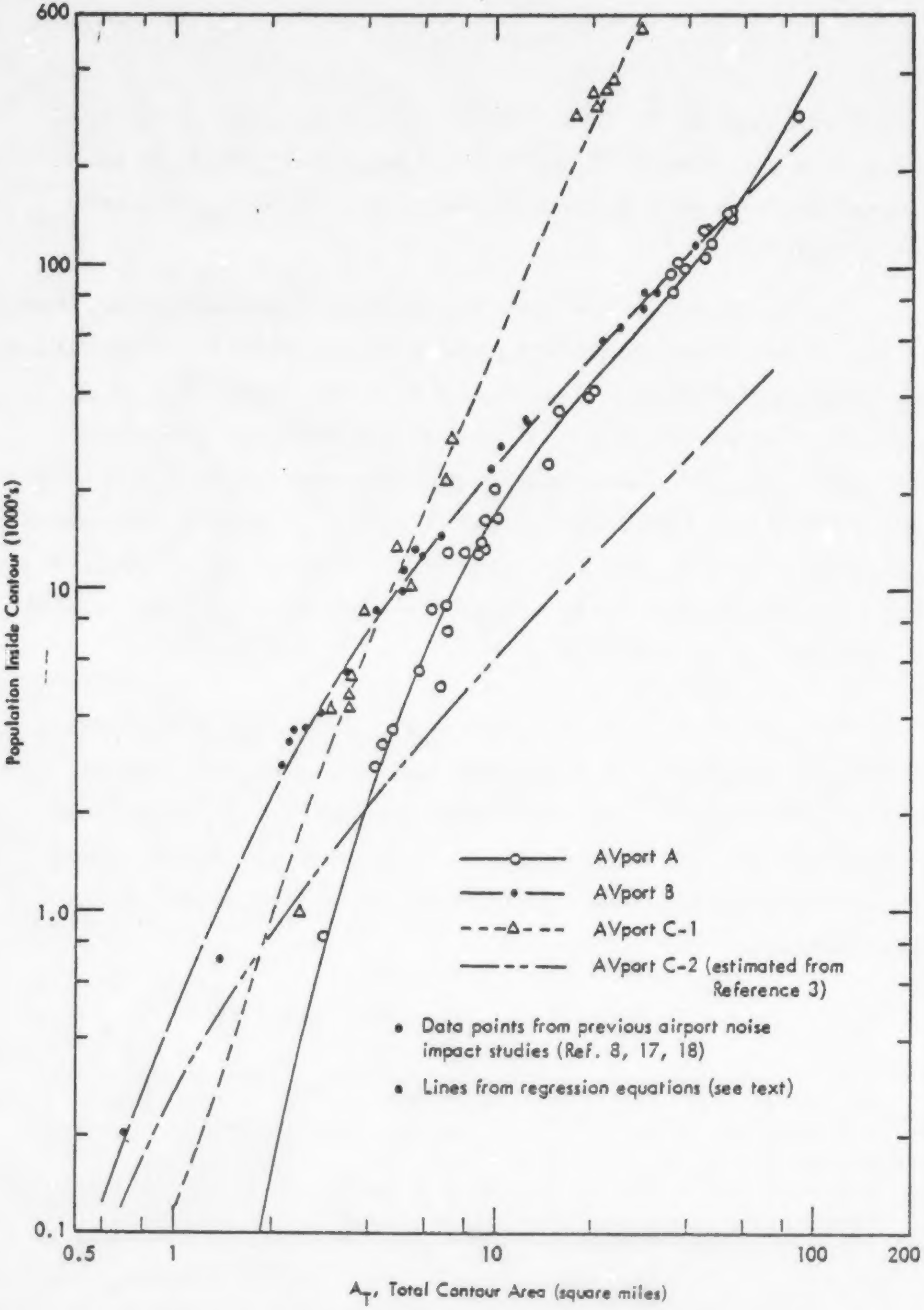


Figure 3.6-2. Comparison of Data Relating Population and Total Contour Area for AVports with Regression Functions Used for Analysis

are identified in Appendix A. The basis for the regression equation for AVport C-2, described in detail in Reference 3, was based on extrapolation of the trends noted from actual data for larger airports utilizing the trends in population profile noted earlier in Figure 3.6-1.

Two final points should be emphasized regarding the population model. First, the model provides the basis for predicting total population inside the total contour area for all operations at an airport, not just those at the busiest runway. Thus, since AVport contour areas are based on the latter, they must first be converted to total airport contour areas before these population prediction models can be applied. This process is defined later under Scaling Methods (Section 3.7). Secondly, the model is not considered reliable for estimating total population within contour areas larger than available from the data base. Thus, estimates of population for L_{dn} contour levels of 60 dB were generally not attempted.

The growth in population from year to year was accounted for by increasing the population exposure estimates in proportion to the expected growth in overall population relative to 1970. The growth factors, obtained from the 1977 Statistical Abstracts Series II projections, are listed below. The Series II projections assume a zero growth replacement birthrate of 2100 per 1000 women plus an annual immigration of 400,000 people.

Assumed Population Growth Factors Relative to 1970

Year	1970	1975	1980	1985	1990	1995	2000
Population Growth Factor	1	1.04	1.08	1.14	1.19	1.23	1.27

3.7 Scaling Methods

Preceding descriptions of noise exposure calculation methods have defined the methods used to calculate noise exposure at average airports (AVports). The methods used to scale the AVport results to the nation are presented in this section.

3.7.1 Method for Scaling Exposure Area

The method for scaling AVport exposure to the nation was developed in Reference 3. This basic method was applied in this study with only slight modification. The first step was to develop an equation expressing the relationship between the weighted number (N_c) of operations at an AVport (i.e., average busy runway) and the total contour area, A_T, resulting from these operations for a particular contour level. The weighted number of operations consisted of the number of operations during the daytime hours (0700–2200) plus 10 times the number of operations during the nighttime (2200–0700). A plot, shown in Figure 3.7-1, of the AVport contour area/weighted AVport operations data points for the L_{dn} 65 dB contour suggested that an expression of the form

$$A_T = a(N_c)^b \qquad (3.7\text{-}1)$$

described the area vs operations relationship where $\underline{a}$ and $\underline{b}$ are constants, and N_c is the weighted number of operations. Such an expression was developed for each year for the L_{dn} 65 dB contours. (Very nearly the same result was obtained for other L_{dn} values.) As explained in the following, $\underline{b}$ is the key parameter of the entire procedure for scaling from AVport contour area to the nation.

Let the contour area for each airport in the i^{th} group with the same number of actual operations N_i be represented by A_i. Let this area vary in a general way with N_i as the function $A(N_i)$. Then, for a population of airports expressed by the distribution $n(N_i)$, indicating n airports with N_i daily operations, the total contour

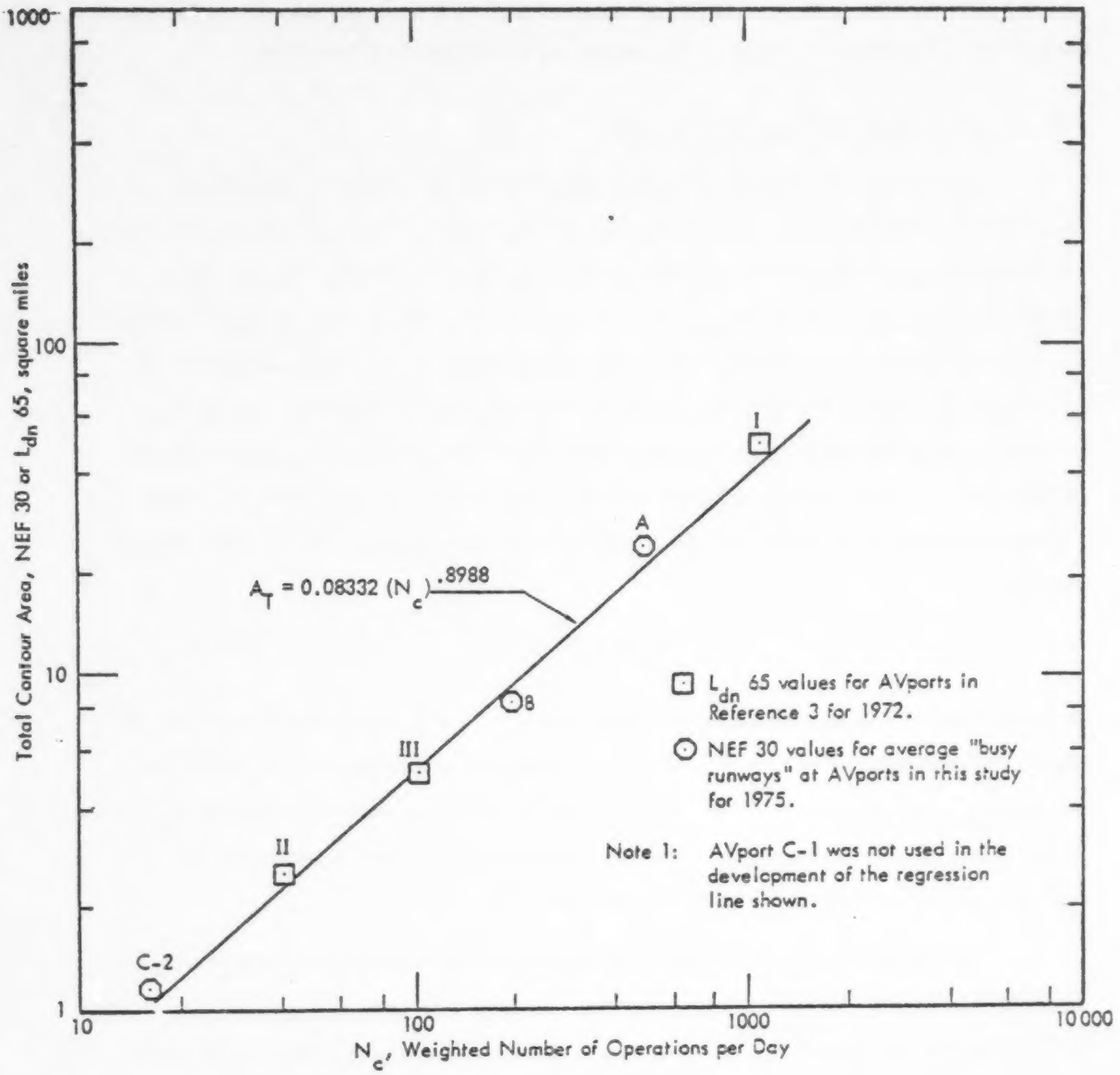


Figure 3.7-1. Total Contour Area Versus Weighted Number of Daily Operations at AVports and Average "Busy Runways" for Baseline Years 1972 and 1975 - A Comparison of Two Studies

area over the nation will be the sum ΣA_i over the i intervals of operations N_i of the contour area per airport $A(N_i)$ times the number of airports with this many operations, $n(N_i)$, or:

$$\sum A_i = \sum_i A(N_i) \cdot n(N_i) \quad , mi^2$$

Carrying out this summation over each of the AVport categories separately and then dividing the resulting sum by the area for the corresponding AVports provides the desired scaling factor. Thus, for the mth AVport, the scale factor, $F_s(m)$, is

$$F_s(m) = \frac{\sum A_{im}}{A_m} \qquad (3.7\text{-}2)$$

where

$\sum A_{im}$ is the sum of the contour areas for all airports in AVport category m

and $m = A, B, C\text{-}1$ or $C\text{-}2$ for the corresponding AVports.

This scale factor will be used as a multiplier to scale the AVport contour area and obtain the unknown total area ΣA_i. How then, do we find ΣA_i so that the scale factor can be computed from the preceding expression?

From equation 3.7-1, the total contour area was related to the total weighted operations N_c by an equation of the form

$$A_T = a(N_c)^b$$

If we assume that the weighted operations N_c is related to the actual operations N_i by a constant K so that

$$N_c = KN_i$$

we can then write out the form for the general function $A(N_i)$ relating contour area and N_i operations as

$$A(N_i) = a(N_c)^b = a(KN_i)^b = a\,K^b\,N_i^b$$

Similarly, for the specific case of the m^{th} AVport, its contour area could be predicted by

$$A_m = a\,K^b\,N_m^{\ b}$$

where $m = A, B, C\text{-}1$ or $C\text{-}2$.

Combining the above expressions provides the desired expression for the scaling factor for the m^{th} AVport as

$$\begin{aligned} F_s(m) &= \frac{\sum A(N_i)_m \cdot n(N_i)_m}{A_m} \\ &= \frac{\sum aK^b N_{im}^b \cdot n(N_i)_m}{aK^b N_m^b} \\ &= \frac{\sum N_i^b \cdot n(N_i)_m}{N_m^{\ b}} \end{aligned} \qquad (3.7\text{-}3)$$

Thus, the scaling factor for the m^{th} AVport is equal to the weighted sum of the number of airports in each category, where the weighting factor is the quantity N_i^b, all divided by the corresponding weighting factor for this AVport, N_m^b. The key variable is simply the exponent b in the expression relating contour area and weighted operations N_c. The other constants a and K cancel out.

The distribution $n(N)_i$ of airports versus jet aircraft operations for 1975 is illustrated in Table 3.7-1. The distribution for future years was estimated as follows.

Table 3.7-1

Distribution of Airports by Number of Aircarrier Jet Aircraft Operations*

Daily Operations			Number of Airports			
Min.	Max.	Geometric Mean	AVport A	AVport B	AVport C-1	AVport C-2
1250	1600	1410	1			
1000	1250	1120		1		
800	1000	890	1			
630	800	710	3		1	
500	630	560	2	1	1	
400	500	445		3		
315	400	355	2	3		
250	315	280	2	4		
200	250	225		7		
160	200	180		8		
125	160	140	2	7		
100	125	110		7		
80	100	89		8		3
63	80	71		11		3
50	63	56		12		4
40	50	45		8		4
31.5	40	35		8		15
25	31.5	28		9		13
20	25	22		7		10
16	20	18		2		20
12.5	16	14		3		21
10	12.5	11		1		21
8	10	9				18
6.3	8	7				11
5	6.3	5.6				11
4	5	4.5		1		4
0	4	0.74		2		21

*Based on data from References 6, 24 and 25.

It was assumed that the basic shape of this distribution profile of number of airports versus operations would remain the same in future years and that the geometric mean number of operations for each interval range of operations in Table 3.7-1 would increase in proportion to the overall growth.

Based on the methods and data outlined above, area scaling factors were computed for all years for Technology Level 1 and Procedure Level 1 for each of the AVports. These same scaling factors were used for all technology and procedure options.

The scaling factors derived for this study are listed in Table 3.7-2. These factors were used to scale the areas computed at the AVports, using the average busy runway operations, to the nation. From there, the areas at the "average airport" were computed by dividing the national area (in an AVport class) by the number of airports in the class. These values, as well as the national estimates, are tabulated in Appendix F. Note that the scaling factors in Table 3.7-2 are always larger than the number of airports in each AVport category since they relate the contour area for operations at just one runway at each AVport to the entire contour area for all airports within each AVport category.

Table 3.7-2

Scale Factors for Extrapolating Area from Average Busy Runway Operations at AVports to the Nation

AVport	Fleet*	YEAR					
		1975	1980	1985	1990	1995	2000
A	M	29.78	28.77	25.69	26.22	25.30	28.80
	E	29.78	28.76	25.70	26.21	29.95	35.86
B	M	131.63	129.11	121.97	123.16	121.11	121.39
	E	131.63	129.14	121.99	123.14	121.13	121.38
C-1	M	3.134	3.44	4.21	4.56	4.72	5.43
	E	3.134	3.49	3.88	4.99	5.75	6.74
C-2	M	231.60	227.03	213.53	215.74	211.85	212.32
	E	231.60	227.04	213.52	215.77	211.84	212.32

*M — Moderate Growth
E — Expansive Growth

3.7.2 Method for Scaling Population Exposure

As described in Section 3.6, the population exposure at an "average airport" can be estimated for each AVport category if the area exposed within a given contour level at the "average airport" is known. The preceding section has described how that area is computed. The exposure areas at the "average airports" were used to compute the population exposures for each of the scenarios. Scaling these population figures to the nation consisted of multiplying them by the number of airports within the respective AVport classes. The total for the nation was computed by summing the national results for all the classes. The exposed population estimates for each scenario, each "average airport" and the nation are tabulated in Appendix F. The overall national population exposure estimates are presented in Section 4.

To summarize, the national population estimates were constructed as follows for each case.

- Computed contour areas for operations on just one runway at each AVport were scaled to the total area for the nation in that AVport category using the area scaling factors in Table 3.7-2.
- These national total contour areas were then divided by the number of airports in each AVport category to obtain the total contour area at what amounts to an "average airport" for each AVport category.
- These "average airport" contour areas were then used with the population regression equations defined in Section 3.6.2 to predict the total population at each "average airport." These are the values tabulated in Appendix F.
- These total "average airport" population values were then scaled to the nation by multiplying by the number of airports in each category.
- The national total was then the sum of these total values for each AVport category.

3.8 Computer Models

Noise exposure was computed in this study at discrete points at 1000-foot intervals on a grid surrounding each AVport. The computer program used to generate the noise exposure values at the grid points around each of the AVports for simulated aircraft operations was the Wyle Integrated Noise Model (INM).* The model was modified to optimize data throughput and to use random storage devices for the large quantities of data that were generated. None of the noise calculation algorithms, such as ground attenuation, engine shielding, velocity correction or basic slant range noise calculations, were compromised. Hand calculations of noise values at selected grid points were compared to results from the modified version and were identical.

The computer program to compute exposure information at the AVports and make extrapolations to the nation was developed during the course of this study. The exposure program (IMPACT) drew on the noise data base generated by the INM and compared the computed levels to preselected L_{dn} levels of 60, 65, 70, 75, and 80 dB. If a selected level was lower than the computed noise level at any grid point, the area associated with each grid point was considered exposed for that selected level. Each grid point examined represented an area of 1 million square feet (.03587 square miles).

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*This computer program was developed under contract to the U.S. Department of Transportation and a revised model of this program has recently been released by the FAA and is entitled "FAA Integrated Noise Model, Version 1." (See Reference 16)

4.0 RESULTS

The objectives of this study were to examine the effects of aircraft noise rulemaking, both current and proposed, and the effects of alternative aircraft flight procedures in terms of both the number of people and total area exposed to noise levels equal to or greater than several criterion levels at and around aircarrier airports in the United States through the year 2000. The population and area estimates computed during the course of this study were primarily intended to provide consistent estimates of noise impact to facilitate comparisons of the effectiveness of a variety of noise abatement alternatives and to indicate trends in the change in this effectiveness over time. Therefore, the first portion of this section will emphasize, graphically, the relationships between the various alternatives considered rather than the specific absolute value of an individual estimate. A comparison of the results of this study with the results of previous studies is discussed, and the detailed results of this study are tabulated at the end of this section.

4.1 The Effects of Rulemaking

To assess the effects of the implementation of aircraft noise rules, three scenarios (defined in Section 3.4.2) were analyzed and two sets of the results of these analyses are shown graphically in Figure 4.1-1 for area and Figure 4.1-2 for population. The magnitude of area and population exposed to three selected values of L_{dn} are given, in bar chart form, for each of the three noise rules considered and for each of the five future years, as well as for each fleet level. In both figures, the lowest bar defines, for convenient reference, the 1975 base case. The aircraft operating procedures were the same for all cases shown and corresponded to Procedure Level 1 (described in Sections 3.5.1 and 3.5.2).

For the 75 FAR 36 cases shown in Figures 4.1-1 and 4.1-2, it was assumed that the 80 FAR 36 and 85 FAR 36 rules were not implemented. For the 80 FAR 36 cases, it was assumed that the 80 FAR 36 rule was implemented in conjunction with the 75 FAR 36 rule. For the 85 FAR 36 cases, it was assumed that all three rules were in effect. Section 3.4.2 discussed the time phased implementation of the 80 FAR 36 and 85 FAR 36 rules.

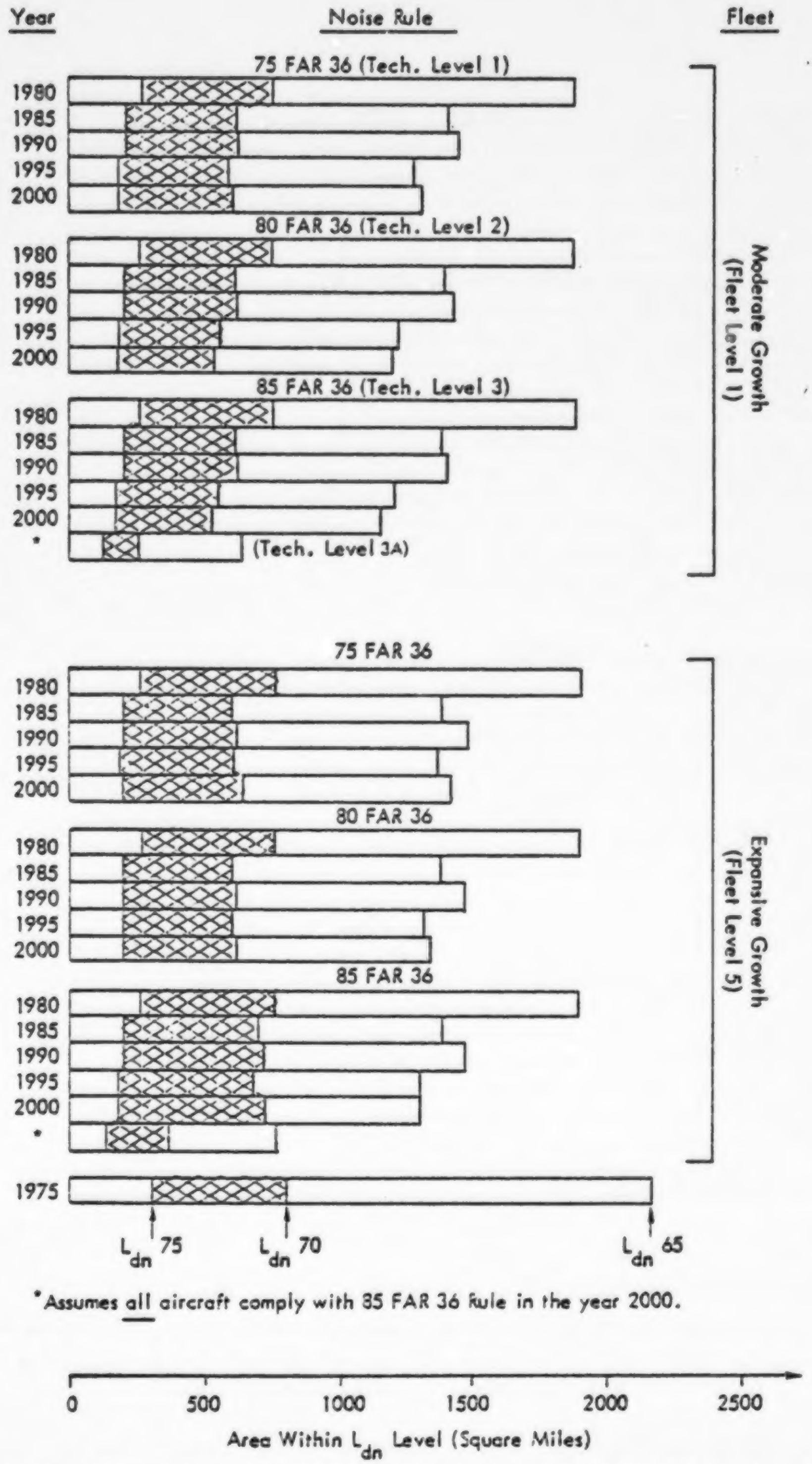
4.1.1 75 FAR 36

Considering, for the moment, Figures 4.1-1 and 4.1-2 and the 75 FAR 36 cases, it is obvious that there is a substantial decrease in area and population within the L_{dn} 65 level between the years 1980 and 1985. This is a direct result of FAR Amendment 91-136 stipulating that all aircraft shall comply with 69 FAR 36 requirements by 1985 unless they are of new type designs which must meet the 75 FAR 36 rule requirements. Since FAR Amendment 91-136 and the 75 FAR 36 rule are assumed for all cases shown, the same relative relationship between the "exposure" in 1980 and 1985 can be seen in all the other cases. The noise exposure in 1990 indicates an increase from that in 1985 for both fleet considerations. The increase in both area and population was caused primarily by an increase in operations nationwide. There is a decrease in affected area and population from 1990 to 1995. This decrease is caused by the assumed retirement of about three-fourths of the aircarrier fleet now operating coupled with the noise dilution effects of the introduction of new type design aircraft during the interim years. This is true for both the Moderate and Expansive Growth fleets. The fact that the exposed area and population both increase from 1995 to 2000, coupled with the fact that over 90 percent of the present fleet is assumed retired in 2000, tends to indicate that added operations are causing the exposure. to rise.

4.1.2 80 FAR 36 and 85 FAR 36

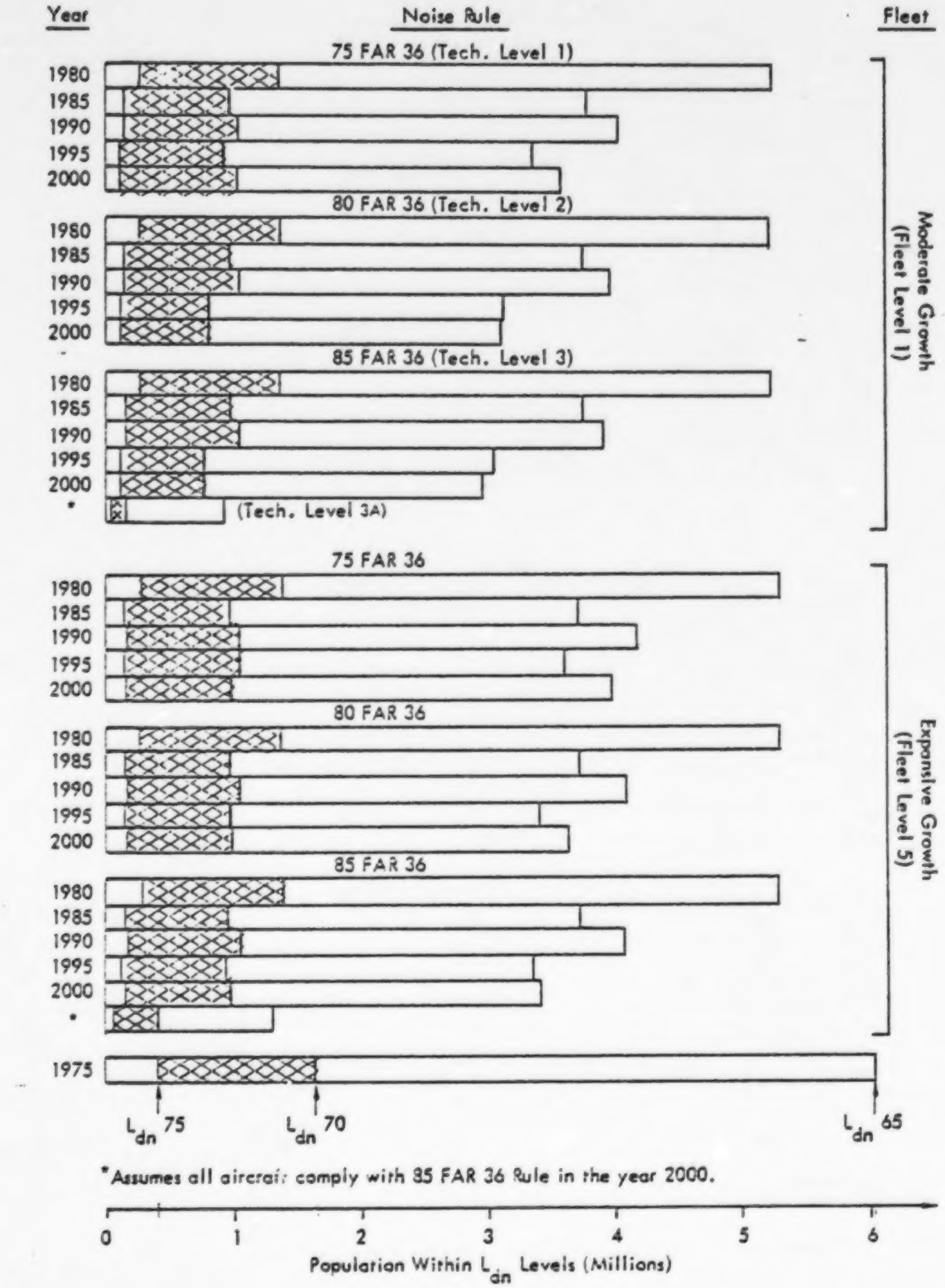
An examination of Figures 4.1-1 and 4.1-2 shows that the 80 FAR 36 and 85 FAR 36 proposed rules shown are, for practical purposes, virtually identical to the 75 FAR 36 case through the year 1990. It is only in the years 1995 and 2000 that the 80 FAR 36 and 85 FAR 36 rules show a significant departure from the 75 FAR 36 rule. For the Moderate Growth fleet in 1995 and 2000, the noise exposure decreases for both years for both the 80 FAR 36 and 85 FAR 36 rules. For the Expansive Growth fleet the area decreases in 1995 and then increases slightly, or remains constant, to the year 2000. The same trend is indicated by the population charts.

The additional case analyzed for this study (Technology Level 3A) assumed that all aircraft comply with the 85 FAR 36 proposed rule in the year 2000. The results are shown graphically in Figures 4.1-1 and 4.1-2 and indicate a substantial decrease in



*Assumes all aircraft comply with 85 FAR 36 Rule in the year 2000.

Figure 4.1-1. Estimated Area in the United States Contained Within L_{dn} Levels for Performance Procedure Level 1 by Fleet and Noise Rule



*Assumes all aircraft comply with 85 FAR 36 Rule in the year 2000.

Figure 4.1-2. Estimated Population in the United States Contained Within L_{dn} Levels for Performance Procedure Level 1 by Fleet and Noise Rule

noise exposure from any of the other scenarios. While it may be unrealistic to presume that all aircraft will comply with this rule in the year 2000, these results indicate that the full effects of the rule would not be apparent until sometime after the year 2000.

4.2 The Effect of Flight Procedures

To assess the effects of different aircraft operating procedures, three scenarios (defined in Section 3.5) were analyzed and two sets of those analyses are shown graphically in Figures 4.1-3 and 4.1-4. The cases shown for the three flight procedures of concern each assume the 75 FAR 36 rule for one case and the 85 FAR 36 proposed rule for the other. The aircraft fleet is the same for all cases and is the Moderate Growth fleet. It should be noted here that for a given flight procedure the changes in exposure from year to year are a result of the noise rule assumed and not because of a change in the flight procedure itself. Also, since it is more convenient to discuss the procedures together rather than singly, this section will not be structured the same as the previous one, but will directly discuss the results shown in Figures 4.1-3 and 4.1-4 in the following paragraph.

The figures clearly show that the ALPA/NWA Max. Cutback procedure has less exposed area and population than the other two procedures through the year 2000 under either noise rule. For the year 2000 the AC91-39 procedure approaches equivalence, on an exposure basis, to the ALPA/NWA Max. Cutback procedure, while the ALPA/NWA Min. Cutback procedure maintains the same relative relationship as the previous years. Although the flight procedure alternatives included unique but relatively minor variations in landing procedures, as defined in Section 3.5.2, the effect of these variations cannot be separated from what is considered to be the dominant influence of alternative takeoff procedures.

4.3 Summary

Figures 4.1-5 and 4.1-6 provide a graphical summary to this section. The figures illustrate the estimated area and population exposure for the three aircraft operating procedures, having cases which assume each of the three noise rules in the years 1995

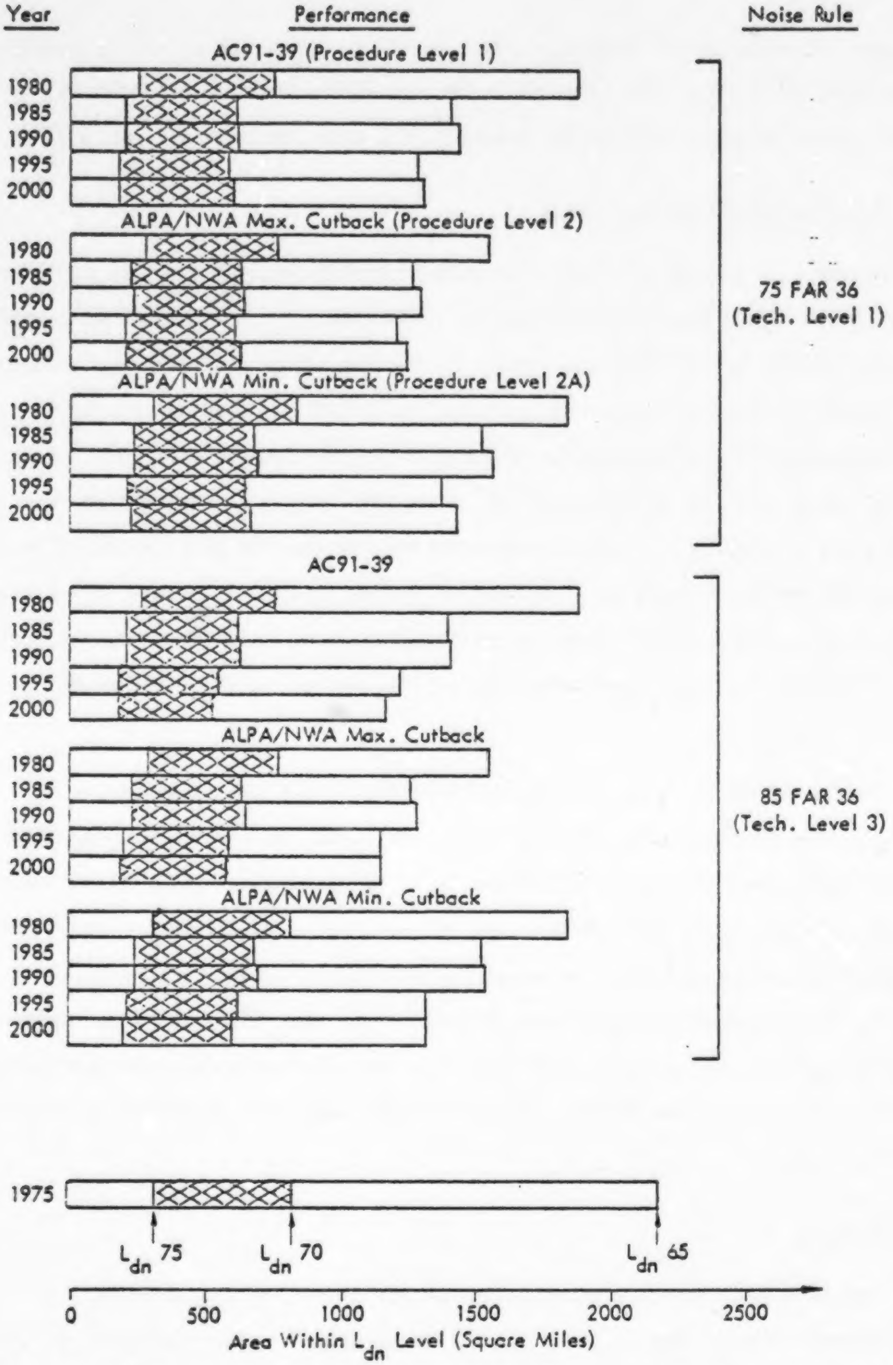


Figure 4.1-3. Estimated Area in the United States Contained Within L_{dn} Levels for Moderate Growth Fleet by Noise Rule and Performance Procedure

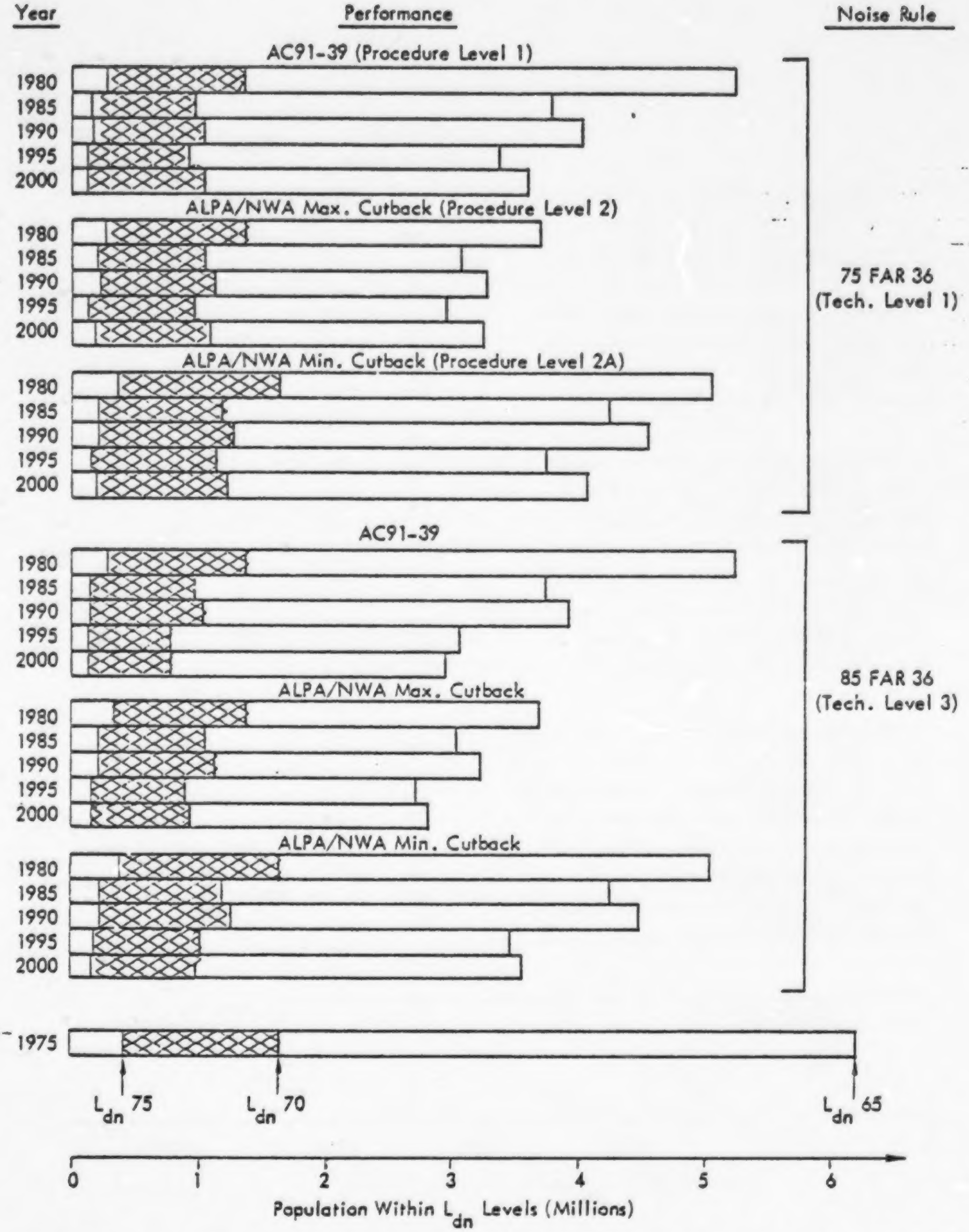


Figure 4.1-4. Estimated National Population in the United States Within L_{dn} Levels for the Moderate Growth Fleet by Noise Rule and Performance Procedure

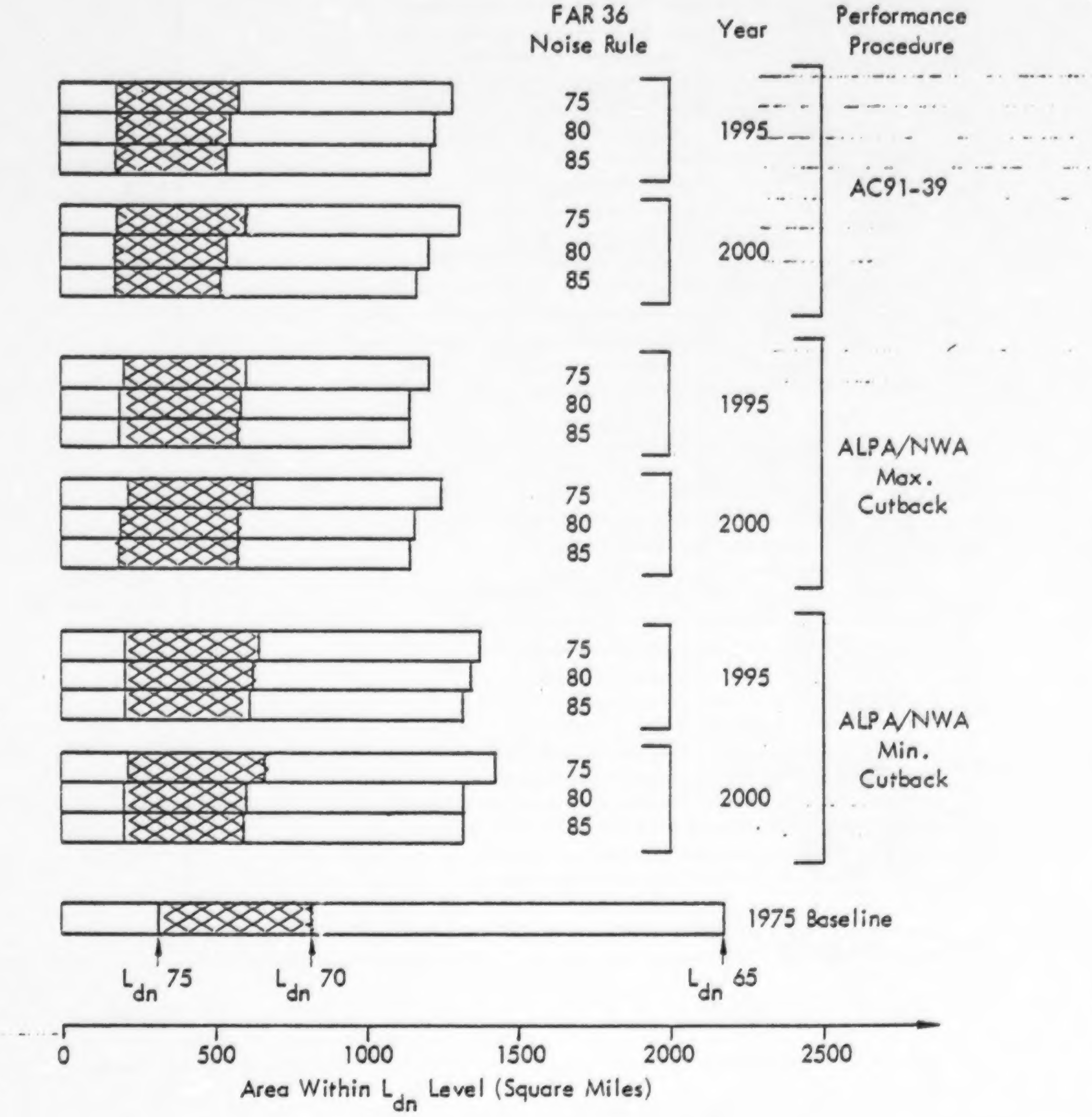


Figure 4.1-5. Estimated Area in the United States Within L_{dn} Level for the Years 1995 and 2000 for the Moderate Growth Fleet

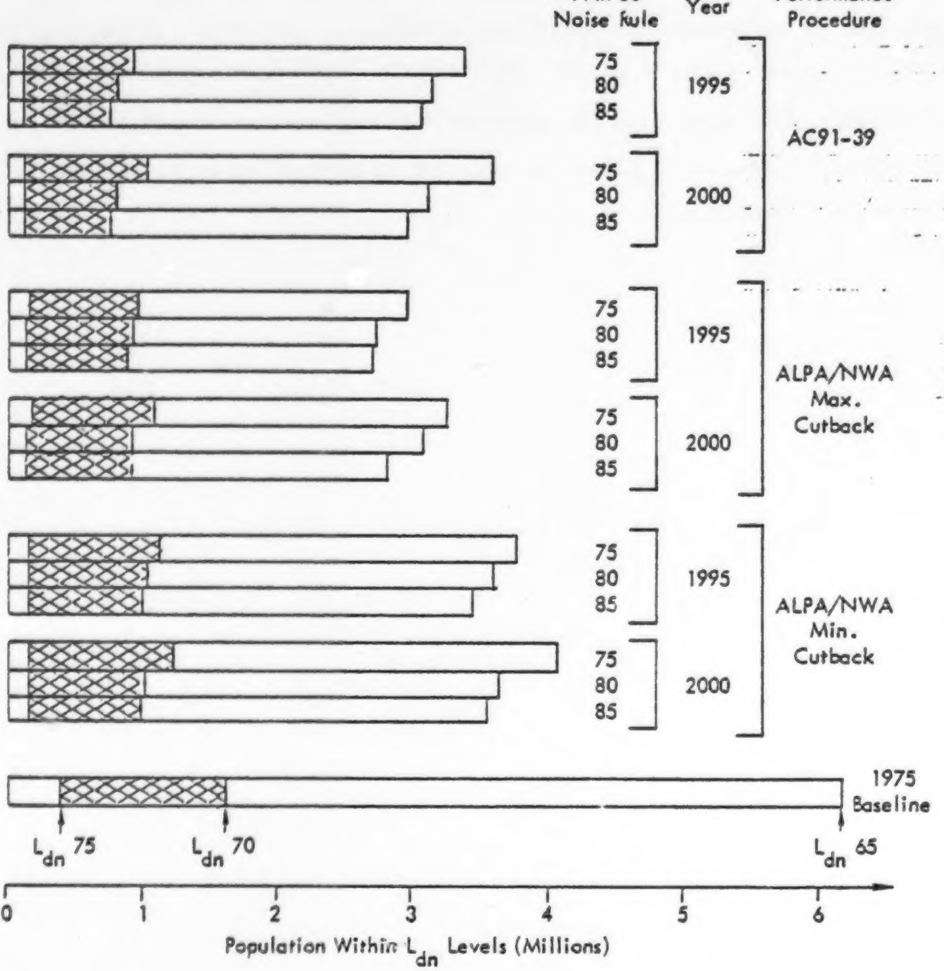


Figure 4.1-6. Estimated Population in the United States Within L_{dn} Levels for the Years 1995 and 2000 for the Moderate Growth Fleet

and 2000. The Moderate Growth fleet is assumed for all cases. The years 1995 and 2000 represent the earliest that any significant difference in noise rules, as they are defined for this study, can be observed. These figures clearly demonstrate that in the years 1995 and 2000, regardless of the performance procedures used, the 80 FAR 36 and 85 FAR 36 proposed rules could provide a significant measure of decreased exposure compared to the 75 FAR 36 rule.

4.4 Comparison of Current and Previous Studies

The current assessment of national noise exposure from aircarrier aircraft operations differs from that of previous studies by Wyle[3, 8, 26] in several respects as summarized in Table 4.4-1. These differences are primarily due to basic differences in objectives of each study and corresponding differences in the methodology employed. For the two studies which projected exposure to 1987,[3,8] the study emphasis was primarily on cost-effectiveness of various noise abatement alternatives. The previous study which projected exposure to the year 2000,[26] evaluated the noise abatement effectiveness of various hypothetical or proposed FAR noise regulations (i.e., 69 FAR Part 36 -5 dB, -10 dB, -15 dB, etc.) as well as the same type of aircraft modifications (i.e., SAM treatment or REFAN) or noise abatement flight procedures (i.e., 6°/3° approach or power cutback on takeoff) considered in the two cost-effectiveness studies.[3, 8]

Recognizing the many differences in methodology employed in these studies, a few useful comparisons can be made. The relative changes in total area within the L_{dn} 65 or NEF 30 contours are shown in Figure 4.4-1 versus time for several of the roughly comparable scenarios from these studies. First, consider the maximum reduction by the year 2000. The earlier "year 2000" study[26] employed overly-optimistic assumptions concerning the relative number of new and much quieter aircraft in the fleet by the year 2000. Thus, the baseline projections of noise exposure for the year 2000 made in this earlier report are no longer considered valid. However, the projected results for the 69 FAR Part 36 -5, -10 or -15 dB cases from the earlier study are worth considering. For the most optimistic case from the current study (Technology Level 4, corresponding to 1985 FAR Part 36 effective for all aircraft, using Procedure Level 1), the relative contour area is reduced to about 29 percent of the 1975 baseline value. This can be compared with a relative contour area from the earlier report[26] of about 10 to 20 percent in the year 2000, relative to a 1972 base, for the cases of 1969 FAR Part 36 -15 or -10 dB respectively for all aircraft. The latter two cases also assumed use of a two segment (6°/3°) approach and an extreme power cutback substantially greater than considered in the current study. Thus, one might very roughly estimate

Table 4.4-1

Comparison of Elements of Wyle Studies on National Airport Noise Exposure from Aircarrier Operations

Study Factors	DOT Report[(1)]	EPA Report, 1975[(2)]	Wyle Report[(3)]	This Report
No. Aircarrier Airports in Sample	23	3	23 - for Contours 82 - for AVport Mix 130 - Census Sample	25 - for Contours 307 - for Mix and Operations at AVports
Final Year	1987	2000	1987	2000
Base Year	1972	1972	1972	1975
Base alternative for Future Years	6°/3°	"No abatement" baseline	All new aircraft meet 69 FAR 36	FAR Amendment 91-136 for existing aircraft and 75 FAR 36 for new aircraft
Abatement Alternatives:				
• Source	• New technology aircraft in 1987 • SAM 3D/8D • REFAN 8D/SAM3D	• New technology aircraft meet FAR 36 in 1987 and FAR 36-10 in 2000 • SAM 3D/8D • REFAN 8D • Demonstrate FAR 36-5, -10, -15, -20	• New technology aircraft meet FAR 36 in 1981 and 1987 • SAM 3D/8D • REFAN 8D (extrapolation only) • New technology aircraft at FAR 36-10 in 1987	New aircraft meet • 80 FAR 36 (Tech. Level 2) or • 80, 85 FAR 36 (Tech. Level 3) from 1985-2000
• Operational	6°/3°	6°/3° approach, PCB, curfews, fleet size and mix change, flight track dispersion	6°/3° and 4° approach Power Cutback Curfews	• 3 Power Cutback Procedures on Takeoff • 2 Approach Altitude, Flap Procedures
• Receiver	Not applicable	Not applicable	Relocation of residents Insulation noise reduction treatment Land acquisition	Not applicable
Demographic Data	Population density - 1970 Census	Not applicable	Population, housing, and land values - 1970 census and forecast	1970 Census & Series II forecast
Aircarrier Fleet Forecast	Estimate to 1987 by detailed analysis of required and available aircarrier transport capacity	Extrapolation beyond 1987 with gradually reducing rate of growth of required capacity, and unit productivity	Forecast of Wyle/DOT report revised to reflect energy crisis	Two levels of fleet growth (moderate and expansive growth)
Airport Operations Forecast	Estimate to 1987 based on detailed analysis of forecast passenger and cargo traffic at each airport and aircraft capacity by type	Extension of forecasts to year 2000 considering growth in aircraft capacity, and improved operating efficiency of airports	Same revision as above	Two levels of airport operations corresponding to fleet growth
General Aviation Airports	Not considered	Not considered	General aviation national model	Not considered
National Extrapolation	Not applicable	Extrapolation to nation based on evaluation of current and forecast profile of aircarrier airports by number of operations	Extrapolation to nation - aircarrier airports and general aviation airports by operation/area and population models	Extrapolation similar to 1975 Wyle Report (Ref. 3)
Noise Measure	NEF 30, 35, 40, 45	NEF 20, 30 and 40	L_{dn} 65 to 85 and Noise Unit (including ambient)	L_{dn} 60 to 85 (based on NEF + 35)

(1) DOT-TST-75-3, Reference 8

(2) EPA 550/9-75-024, Reference 26

(3) Wyle Research 75-9, Reference 3

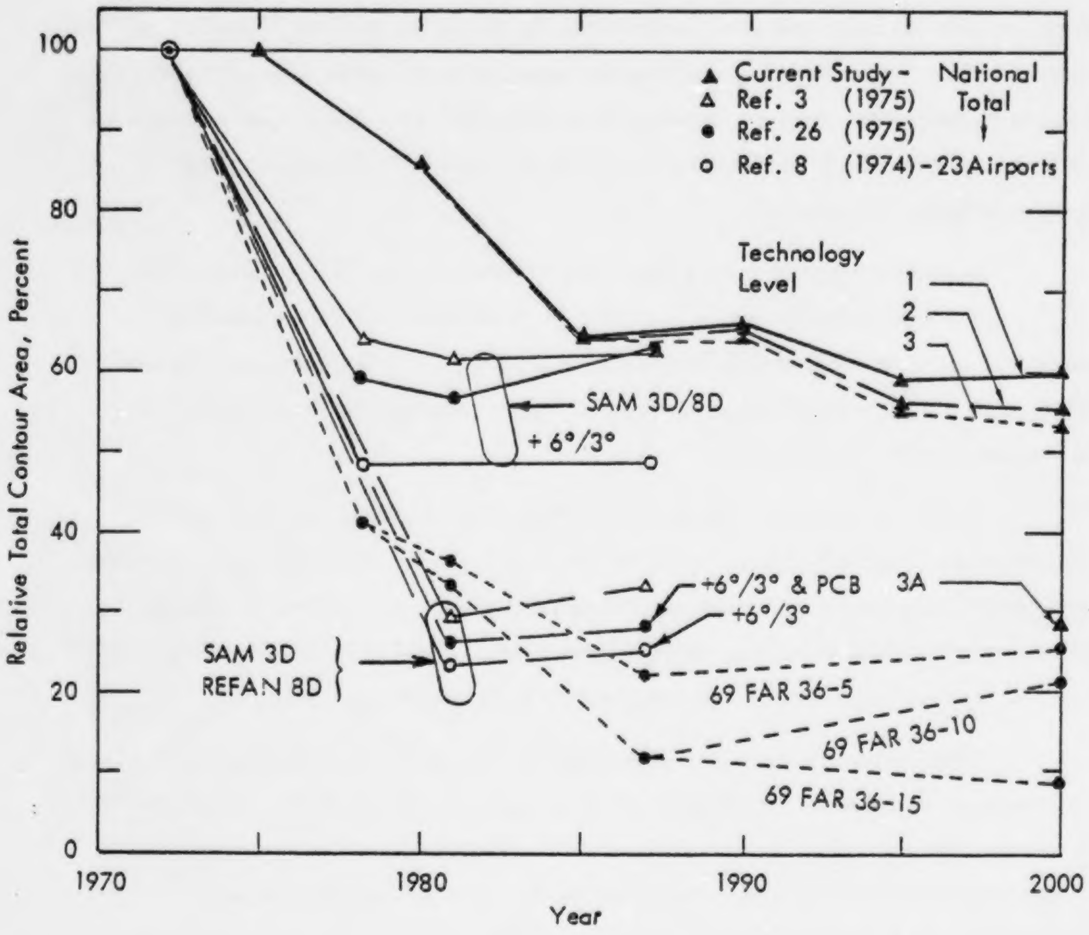


Figure 4.4-1. Comparison of Relative Changes in Total Contour Area from Current Study and Selected Cases from Three Earlier Estimates of National Noise Exposure by Aircarrier Aircraft

that application of maximum feasible noise reduction measures known at this time might be able to reduce the total contour area for the nation to 20 to 30 percent of current values. However, this would not be expected to be achievable until well beyond the year 2000 since the more realistic projections of possible noise exposure for this year, represented by the application of 75, 80, or 85 FAR 36 rules, indicate substantially less reduction.

Secondly, consider a more short term viewpoint, say, for the period 1985-1987. The previous studies show a reduction to 60 to 65 percent of the baseline contour area for the case of only SAM retrofit to JT-3D and JT-8D engines. As one might expect, this is about the same as should be achieved by the 1975 FAR Part 36 rule coupled with FAR Amendment 91-136.

Lastly, for the same time period of 1985-1987, Figure 4.4-1 makes quite clear that a substantially greater reduction in noise exposure would be achieved if other more drastic changes in noise abatement were implemented (i.e., REFAN, etc.). However, as verified in the cost-effectiveness studies, these more effective measures were not economically viable when required for the entire aircarrier fleet.

One final comparison is in order between the current study and previous efforts. This bears on estimates of the absolute value of total area within the L_{dn} 65 or NEF 30 contours across the nation in the baseline (1972-1975) period and the corresponding number of people residing within these boundaries. The previous Wyle report,[3] prepared for the Economics Analysis Division of EPA, contains such values for 1972 which can be compared with values from the current study. The resulting comparison is summarized below.

Data Source	Baseline Year	Total Contour Area, mi^2	Total Population, 10^6
Reference 3	1972	2741	7.09
Current Study	1975	2169	6.17
Percent Difference		-21%	-13%

The differences between these baseline noise exposure estimates for the nation are due to differences in analysis procedures, noise metrics, and aircraft noise data as outlined in the following.

Difference in Studies	Percent Change in Contour Area re Reference 3 Value
Current study grouped aircraft into fewer categories (i.e., 4-engine narrow body turbofan instead of B707, DC-8, etc.) for purposes of estimating noise.	-17
Current study had different aircraft mix (i.e., no pure turbojets, etc.).	-14
Current study included simulation of dispersed or curved flight tracks instead of straight-in, straight-out.	-5
Current study computed NEF 30 contours, 35 dB added to correct to L_{dn} 65.	+3
B707, DC-8 Noise Exposure Levels underestimated in previous study.	+15
Other miscellaneous differences, scaling methods, No. of operations, operating procedures, etc.	-3
	-21%

Comparable results would also be obtained for the breakdown in the difference in population estimates.

An important point is brought out quite clearly by this comparison. Relatively minor differences in modeling approaches can cause significant changes in absolute values of noise exposure which make comparisons of such absolute values between dissimilar studies extremely difficult. Note also that the final difference in total contour area of 21 percent between the current study and that of Reference 3 corresponds to a difference in noise levels of about 1.2 dB.

4.5 Tabulated Results

This section contains the estimates of national population and area exposed to selected noise levels for all scenarios. The titles for each table describe the scenario in terms of Procedure Level (see Section 3.5), Technology Level (see Section 3.4), and Fleet Level (1 = Moderate Growth, 5 = Expansive Growth). Table 4.5-1 lists the estimated national exposure values for the year 1975 only. Tables 4.5-2 through 4.5-25 list the estimated national exposures for the future study years and scenarios. It should be noted that, for most of the aforementioned tables, the population estimates for the L_{dn} 60 noise level are not given. It was felt that while the formulae to estimate exposed population could be applied and the results reported, there was, however, insufficient information available to assess the validity of those results. In general, the area values obtained for the L_{dn} 60 noise levels at the various AVports substantially exceeded those for which the formulae were derived. Thus, application of the formulae beyond their range of proven validity was felt to be potentially misleading. On the other hand, the population values shown for all of the other noise levels represent interpolations based on the derived formulae, and as such, should represent valid trend indicators as well as reasonably accurate estimates of the absolute values of exposed population.

Table 4.5-1

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for 1975

Noise Level (L_{dn})	Area (mi^2)	Population (thousands)
60	-5,314 [1]	
65	2,169	6,172
70	806	1,620
75	310	393
80	155	68

Note 1. Negative signs indicate noise level contour has exceeded outer boundary of grid points included in calculation; hence, area may exceed stated value.

Table 4.5-2

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 1 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	- 4,682	3,352	3,405	2,947	2,984
	Population					
65	Area	1,873	1,397	1,431	1,279	1,304
	Population	5,224	3,775	4,022	3,354	3,581
70	Area	754	610	618	584	605
	Population	1,364	961	1,033	913	1,026
75	Area	255	200	201	179	179
	Population	267	148	157	121	126
80	Area	141	115	117	114	115
	Population	54	35	38	36	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-3

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 1 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,074	2,451	2,488	2,324	2,379
	Population					
65	Area	1,536	1,260	1,290	1,197	1,240
	Population	3,673	3,064	3,260	2,946	3,240
70	Area	757	634	641	601	617
	Population	1,366	1,041	1,114	968	1,074
75	Area	277	224	228	203	206
	Population	314	197	213	164	179
80	Area	142	127	128	114	118
	Population	55	45	49	36	39

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-4

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 1 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,063	3,387	3,429	3,000	3,060
	Population					
65	Area	1,829	1,514	1,550	1,372	1,418
	Population	5,047	4,247	4,537	3,750	4,066
70	Area	829	671	681	641	655
	Population	1,625	1,180	1,265	1,115	1,224
75	Area	295	226	228	204	208
	Population	359	203	213	167	183
80	Area	144	127	128	114	117
	Population	57	45	49	36	39

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-5

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 2 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	- 4,682	3,350	3,354	2,760	2,750
	Population					
65	Area	1,873	1,388	1,420	1,217	1,200
	Population	5,224	3,745	3,970	3,116	3,109
70	Area	754	610	618	551	540
	Population	1,364	961	1,027	800	802
75	Area	255	200	200	176	173
	Population	267	148	153	116	118
80	Area	141	115	117	112	115
	Population	54	35	38	35	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-6

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 2 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,074	2,451	2,460	2,252	2,223
	Population					
65	Area	1,536	1,249	1,276	1,144	1,150
	Population	3,673	3,029	3,212	2,713	2,855
70	Area	757	634	639	587	574
	Population	1,366	1,041	1,102	921	923
75	Area	277	224	224	190	188
	Population	314	197	201	142	143
80	Area	142	127	128	114	115
	Population	55	45	49	36	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-7

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 2 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,063	3,387	3,402	2,922	2,865
	Population					
65	Area	1,829	1,514	1,533	1,342	1,320
	Population	5,047	4,247	4,467	3,586	3,627
70	Area	829	671	675	616	600
	Population	1,625	1,180	1,246	1,028	1,015
75	Area	295	226	226	201	197
	Population	359	203	205	161	160
80	Area	144	127	128	114	115
	Population	57	45	49	36	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-8

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 3 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	- 4,682	3,350	3,341	2,749	2,620
	Population					
65	Area	1,873	1,388	1,402	1,206	1,157
	Population	5,224	3,745	3,908	3,045	2,952
70	Area	754	610	618	541	518
	Population	1,364	961	1,027	768	757
75	Area	255	200	200	173	173
	Population	267	148	153	112	116
80	Area	141	115	117	112	106
	Population	54	35	38	35	29

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-9

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 3 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,074	2,451	2,460	2,224	2,194
	Population					
65	Area	1,536	1,249	1,276	1,141	1,142
	Population	3,673	3,029	3,212	2,702	2,796
70	Area	757	634	639	576	573
	Population	1,366	1,041	1,102	887	912
75	Area	277	224	224	190	184
	Population	314	197	201	142	138
80	Area	142	127	128	114	115
	Population	55	45	49	36	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-10

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 3 Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,063	3,387	3,402	2,865	2,784
	Population					
65	Area	1,829	1,514	1,533	1,308	1,306
	Population	5,047	4,247	4,467	3,443	3,550
70	Area	829	671	675	606	590
	Population	1,625	1,180	1,246	994	975
75	Area	295	226	226	201	186
	Population	359	203	205	161	141
80	Area	144	127	128	114	115
	Population	57	45	49	36	38

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-11

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 3A Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,284
	Population					3,096
65	Area					626
	Population					920
70	Area					251
	Population					154
75	Area					125
	Population					49
80	Area					11
	Population					0

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-12

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 3A Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,265
	Population					2,963
65	Area					723
	Population					1,183
70	Area					287
	Population					226
75	Area					136
	Population					62
80	Area					11
	Population					0

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-13

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 3A Fleet Level 1

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,441
	Population					3,660
65	Area					738
	Population					1,241
70	Area					289
	Population					230
75	Area					136
	Population					62
80	Area					11
	Population					0

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-14

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 1 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	- 4,725	3,342	3,555	3,165	3,295
	Population					
65	Area	1,889	1,376	1,483	1,367	1,410
	Population	5,277	3,699	4,162	3,595	3,971
70	Area	756	596	628	610	642
	Population	1,375	953	1,045	1,017	1,065
75	Area	258	199	206	188	196
	Population	274	147	168	138	159
80	Area	141	116	119	116	122
	Population	54	35	38	37	42

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-15

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 1 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,094	2,402	2,550	2,449	2,548
	Population					
65	Area	1,541	1,243	1,316	1,302	1,343
	Population	3,703	2,964	3,392	3,246	3,568
70	Area	780	619	666	661	682
	Population	1,431	1,028	1,193	1,117	1,244
75	Area	277	215	232	217	217
	Population	312	179	221	196	204
80	Area	144	118	130	127	131
	Population	57	36	50	48	52

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-16

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A   Technology Level 1   Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,108	3,304	3,519	3,187	3,292
	Population					
65	Area	1,836	1,503	1,571	1,489	1,546
	Population	5,102	4,140	4,612	4,091	4,454
70	Area	856	659	708	692	723
	Population	1,702	1,184	1,353	1,232	1,388
75	Area	295	217	242	219	229
	Population	358	186	246	201	228
80	Area	144	118	130	127	131
	Population	57	36	51	48	52

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-17

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 2 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	-4,725	3,342	3,502	2,991	3,006
	Population					
65	Area	1,889	1,376	1,457	1,318	1,339
	Population	5,277	3,699	4,061	3,404	3,620
70	Area	756	596	624	594	623
	Population	1,375	953	1,032	952	986
75	Area	258	199	204	186	191
	Population	274	147	164	135	150
80	Area	141	116	119	116	122
	Population	54	35	38	37	42

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-18

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 2 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,094	2,402	2,526	2,398	2,453
	Population					
65	Area	1,541	1,243	1,308	1,268	1,290
	Population	3,703	2,964	3,341	3,107	3,349
70	Area	780	619	654	646	654
	Population	1,431	1,028	1,152	1,057	1,124
75	Area	277	215	230	203	203
	Population	312	179	216	166	173
80	Area	144	118	128	118	131
	Population	57	36	49	38	52

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-19

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 2 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,108	3,295	3,485	3,081	3,107
	Population					
65	Area	1,836	1,503	1,564	1,440	1,464
	Population	5,102	4,140	4,559	3,878	4,103
70	Area	856	659	694	676	679
	Population	1,702	1,184	1,305	1,166	1,219
75	Area	295	217	232	205	206
	Population	358	186	223	193	178
80	Area	144	118	128	118	131
	Population	57	36	49	38	52

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-20

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 3 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	- 4,725	3,342	3,490	2,938	2,925
	Population					
65	Area	1,889	1,376	1,457	1,301	1,292
	Population	5,277	3,699	4,061	3,341	3,403
70	Area	756	596	624	584	622
	Population	1,375	953	1,032	914	979
75	Area	258	199	204	176	182
	Population	274	147	164	118	131
80	Area	141	116	117	116	121
	Population	54	35	38	37	40

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-21

Estimated Population and Area in the United States Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 3 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	3,094	2,402	2,526	2,356	2,410
	Population					
65	Area	1,541	1,243	1,306	1,261	1,273
	Population	3,703	2,964	3,335	3,058	3,273
70	Area	780	619	654	621	648
	Population	1,431	1,028	1,152	1,014	1,090
75	Area	277	215	230	201	202
	Population	312	179	216	163	171
80	Area	144	118	128	116	121
	Population	57	36	49	37	40

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-22

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 3 Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area	4,108	3,295	3,485	3,037	3,051
	Population					
65	Area	1,836	1,503	1,562	1,438	1,439
	Population	5,102	4,140	4,553	3,855	4,000
70	Area	856	659	694	661	673
	Population	1,702	1,184	1,305	1,150	1,184
75	Area	295	217	232	201	205
	Population	358	186	223	163	175
80	Area	144	118	128	116	121
	Population	57	36	49	37	40

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-23

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 1 Technology Level 3A Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,539
	Population					3,951
65	Area					762
	Population					1,305
70	Area					366
	Population					292
75	Area					141
	Population					66
80	Area					55
	Population					7

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-24

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2 Technology Level 3A Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,565
	Population					3,926
65	Area					843
	Population					1,582
70	Area					437
	Population					444
75	Area					152
	Population					82
80	Area					64
	Population					12

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

Table 4.5-25

Estimated Population and Area in the United States
Exposed to Noise Levels from Aircarrier Aircraft Operations for

Procedure Level 2A Technology Level 3A Fleet Level 5

Noise Level (L_{dn})	Exposure Parameter	YEAR				
		1980	1985	1990	1995	2000
60	Area					1,773
	Population					4,782
65	Area					874
	Population					1,693
70	Area					439
	Population					450
75	Area					152
	Population					82
80	Area					64
	Population					12

Note 1. Area given in square miles (statute). Negative areas indicate that noise level exceeded grid boundary.

Note 2. Population given in thousands.

5.0 CONCLUSIONS

- Since the 80 FAR 36 and 85 FAR 36 rules do not impose restrictions on aircraft of existing type design, if promulgated, their substantial effect will not be realized fully until a large percentage of the existing type design aircraft are replaced by new type design aircraft. As indicated in this study, the noticeable benefit of 80 FAR 36 and 85 FAR 36 begins near the end of the century and would not be expected to achieve the full potential until some later date.
- While the "retrofit/replacement" rule * achieves dramatic early results (within 5 to 8 years) by imposing requirements on currently operating aircraft to meet 69 FAR 36 by 1985, further benefits are realized by the 75 FAR 36 rule which imposes even more stringent regulations on post-1975 new type design aircraft. While the benefits of these two rules are immediate and ongoing, the results of this study indicate that the effect of increased operations, even in the Moderate Growth fleet, will counteract the decrease in source noise levels around the end of the century.
- A substantial immediate benefit can be realized through the optimization of aircraft flight procedures. A periodic review of the procedures will be necessary to maintain the optimum benefit of flight procedure alternatives as source noise levels decrease.

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*FAR Amendment 91-136 (41 F.R. 56046: December 23, 1976)

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